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TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 393
The Bridge Disaster at Victoria, B. C. (illustrated). 394
Railway Yards and Terminals (illustrated)..... 395
A Rotary Screw Pump (illustrated)..... 398
Economy in Car Lighting..... 398
A Flush Fitting Door for Freight Cars (illustrated). 399
Legal Decisions of Interest to Engineers..... 399
Burnside Shops, Illinois Central R. R. (with inset, illustrated)..... 402
Twelve-Wheel Locomotive, St. Lawrence & Adirondack Ry. (illustrated)..... 405
Steel Cab for Locomotives, Canadian Pacific Ry. (illustrated)..... 406
Purifying Water for Locomotives (illustrated)..... 406
Annual Convention of the New England Water-Works Association 407
EDITORIAL NOTES 400
Radial-Stay Locomotive Boilers—Lessons of the Bridge Disaster at Victoria, B. C.—The Overcrowding of Street Cars—Terminals of the New East River Bridge—Status of the Rapid Transit Question in New York—Rapid Transit Traffic in New York.
EDITORIAL..... 401
The Construction and Operation of Railway Yards.
LETTERS TO THE EDITOR..... 402
Growth of Passenger Traffic in New York City—Civil Service Examinations.

THE BOSTON UNION STATION bill has been signed by the Governor of Massachusetts, and this empowers the officers of the Boston & Albany R. R. and New York, New Haven & Hartford R. R. (including the Boston & Providence, Old Colony and New England railways) to co-operate under the name of the Boston Terminal Co., with a capital stock of $500,000, to build a union station at Atlantic Ave. and Summer St. The general plans for the station were described in our issue of March 26.

THE ELEVATION OF TRACKS IN NEWARK, N. J., has been carefully planned by the engineers of the Pennsylvania R. R. and Central R. R. of New Jersey, working with Mr. A. P. Boller, as engineer for the city. The Pennsylvania R. R. will have an elevated structure about 8,000 ft. long, with a headway of 14 ft., some of the cross streets being depressed. The greatest change in elevation will be 16.7 ft. above the present grade. About 20 street bridges will be required. The tracks will have grades of 0.6 to 0.8%, with an incline of 2½% to reach the surface tracks of the freight yards. On the Central R. R., one street will be closed and another depressed 10.75 ft., with grades of 5%, it being impracticable to raise the tracks at this point more than 3 ft., owing to the connections with the yard tracks.

THE WESTINGHOUSE ELECTRIC LOCOMOTIVE, built by the Baldwin Locomotive Works and equipped by the Westinghouse Electric & Mfg. Co., is to be examined by officers of the New York elevated railways, with a view to having service trials made. The engine resembles a large street car mounted on two four-wheel trucks, having heavy steel frames, each truck having two Tesla polyphase motors.

NEW TRACKS ON THE BROOKLYN BRIDGE are to be laid during July and August, when the traffic is light, the trains being run on one track at a time, with a headway of 15 instead of 1½ to 6 minutes. The present 56-lb. rails which have been in use for 13 years will be replaced with 70-lb. rails on creosoted ties. There will be four rails to each track, forming two gantleted tracks with rails 5¾ ins. c. to c., the gantleted tracks being spread at the station to reach opposite sides of the two platforms. By this arrangement no switches will be required to divert the trains to one or other of the two arrival tracks. There will be two independent cables. It is to be hoped that a better floor system will be installed, as the present floor with small short ties, widely spaced, might lead to a bad accident in case of derailment, there being ample space for the tracks to drop so far as to throw a car against the trusses. This would probably not endanger the structure, but might crush in the car and injure the passengers. All the timber guard rails have already been taken up.

THE LOOP TERMINAL of the Brooklyn Elevated R. R., at the Brooklyn Bridge station, has been opened and terminal switching is thus avoided. The trains run to the Sands St. station, then round the loop to the High St. station and on to the main line again. The two tracks are used by the Lexington Ave. and Fifth Ave. trains respectively, so as to avoid confusion among the passengers.

THE FIRST VAUCLAIN COMPOUND LOCOMOTIVE, on the four-cylinder system, was built in 1889, and this system has since had a steady growth, having been applied to engines of all kinds and sizes and for every variety of service, from ordinary freight and passenger service to suburban service and for pusher engines on steep grades, as well for street railway motors. A large number of engines have been built for foreign countries, the greater number of these being probably in Brazil and Russia, but engines have also been built for railways in Australia, New Zealand, Japan, Chile and Mexico. According to a statement issued by the Baldwin Locomotive Works, 615 locomotives on this system had been built or ordered up to Feb. 20, 1896; the numbers for each year having been as follows:

1889	1	1893	160
1890	3	1894	30
1891	84	1895	51
1892	213	1896 (Feb. 20)	73

THE BOSTON SUBWAY ACT was declared constitutional by the Massachusetts Supreme Court on June 15, in a suit brought by a taxpayer against the Rapid Transit Commissioners.

AN ELECTRIC CONDUIT RAILWAY on Wentworth Ave., Chicago, is proposed by the General Electric Co., and the company will agree to pave the street from curb to curb, remove snow, keep the street clean, and maintain one electric light in the middle of each block. Part of this liberality is due to the fact that the Chicago City Ry. Co. wants to build a trolley line on the same street, and has also offered to pave the street between curb lines.

THE NEW EXPRESS DELIVERY system, inaugurated by the Brooklyn Heights R. R. Co., began operations on June 15; six cars were put in service at the start for the carriage of goods between stations. The results of this experiment, which was noted at length in our issue of May 14, will be watched with interest.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was caused by runaway cars on the Baltimore & Potomac R. R., at Baltimore, Md., June 9. A freight train of 32 cars had started for Washington, and was in the tunnel when a brake hose burst, causing the application of the brakes on the first 12 cars. The rear cars were not fitted with power brakes and crowded up against the others with such force as to break a coupling pin. The 20 cars then ran back down the grade to the freight yards, passing through the Union station, and were switched onto the Northern Central R. R. tracks by a towerman, causing them to run to the Calvert station yards. The speed had been checked by a brakeman on the runaway cars, but a passenger car and the bumpers in the station were badly wrecked when the freight cars entered the station. One man was killed.

A LOCOMOTIVE BOILER EXPLOSION occurred June 3 on the Southern Pacific Ry. The engine was attached to a gravel train and was working near Schuman, Cal.—— The Board of Railroad Commissioners of New York State has reported that the explosion of a locomotive boiler on the Delaware, Lackawanna & Western R. R., Feb. 19, was due to low water in the boiler. The Board recommends that gage cocks be placed on the boiler heads of all culm burning locomotives at present without them; and that all locomotive boilers be examined at least once a month, and that the staybolts be tested carefully and a record kept of the examination.

A RAILWAY BRIDGE carrying the Norfolk & Western R. R. over Little Otter River, near Lynchburg, Va., collapsed June 5 owing to a collision of the two sections of a parted freight train. About 20 cars went down and one man was killed.

AN EXPLOSION OF DYNAMITE at Lilly, Pa., where work is in progress for the straightening of the Pennsylvania R. R., occurred June 9, by which one man was killed and six were injured. A premature blast caused the explosion of 180 cans of dynamite.

AN ELEVATOR in the American Surety Building, New York city, was suddenly stopped at the fourth floor, on June 13, by the accidental application of the safety grip. The car was on its down trip and stopped at the fourth floor.

THE NEW EAST RIVER BRIDGE, between New York city and Brooklyn will extend from Delancey St., New York, to 5th St., Brooklyn. The clear span will be 1,610 ft.; the maximum height above high water, 135 ft., and the height from high water to top of towers, 332 ft. There will be two tracks for through trains of the elevated railways and four for electric street cars; two footwalks, two carriageways, and perhaps a bicycle path. According to report the four cables will be of No. 6 straight steel wires in strands of 271, each cable having 19 strands (or 5,149 wires) and the finished diameter being about 18 ins., or about 3 ins. more than that of the Brooklyn Bridge cables.

A SECOND 48-IN. STEEL CONDUIT has been completed by the East Jersey Water Co., from its Macopin intake to Pompton Notch, a distance of 5½ miles. This has been connected at that point with the original conduit built to deliver 50,000,000 gallons daily to the Newark reservoirs, and has so far made up the deficiency in carrying capacity as to increase the flow from some 36,000,000 to 45,000,000 gallons a day, the grade on the lower part of the line being better than on the upper, or duplicated portion. Beginning with May 31 the East Jersey Water Co. has been supplying Jersey City with from 20,200,000 to 23,400,000 gallons a day. By November the company expects to complete its second conduit the full distance, when it will have a conduit-carrying capacity of 70,000,000 gallons a day. The company states that the calculated yield of the Pequannock drainage area, 50,000,000 gallons, will not be equal to the combined demands of Newark, Jersey City and smaller towns dependent on it longer than this year. It estimates the combined daily consumption as 300,000 gallons in excess of the 50,000,000 gallons in 1897, 3,000,000 in 1898, 5,600,000 in 1899, and 8,500,000 gallons in 1900. Jersey City being the last municipality to contract for water, it will have to stand the deficiency, the company states. The company offers to make this up by adding to the supply conduits, "near Little Falls, water of unexceptionable purity."

A WATER FILTRATION PLANT FOR ST. LOUIS is provided for by an ordinance introduced in the Board of Public Improvements by Mr. M. L. Holman, M. Am. Soc. C. E., Commissioner of Public Works. Regarding the capacity and character of the plant, the ordinance states:

> The plant when completed shall have a capacity of 100,000,000 gallons in 24 hours. The designs for the plant shall be predicated upon the use in the settling basins of sulphate of alumina or potash alum as a coagulant, and the covering of the reservoirs in which the filtered water is stored.
>
> The filter plant shall be built in installments from time to time in accordance with plans to be approved by the Board of Public Improvements.

Mr. Holman is reported as saying that whatever experimental work may need to be done should be carried out by the city rather than calling upon private enterprise.

BIDS FOR THE NEW WATER CONDUIT for Brooklyn were ten in number and are given, by totals, in our Construction News Supplement. The conduit is in connection with an increase of the present source of supply and will be about 74,000 ft. long. Bids were invited for a single 66-in. steel pipe, coated either with asphalt or with the Sabin coating of baked Japan varnish; and for a double and a single line of 48-in. cast-iron mains. The lowest bid for the steel conduits was $801,979 for the Sabin and $779,629 for the asphalt coating. This bid was put in by John McNamee, of Brooklyn, who did not bid for a double line of 48-in. cast-iron pipe, but offered to put in a single line for $701,088. The lowest bids for cast-iron pipe were $1,292,261 for a double and $677,261 for a single line. The bidders making this offer, J. P. Cranford & Son, of Brooklyn, named $930,823 and $893,573, respectively, for Sabin and for asphalt coated steel pipe, 66 ins. in diameter. T. A. & R. G. Gillespie, of Pittsburg, Pa., who have laid far more large steel conduits than any one else in this country, wished $1,070,985 for Sabin, and $996,485 for asphalt coated pipe. There were only two sets of bids higher than these for the steel pipe, and no one else bid so high as Gillespie Bros. for iron pipe, $1,469,567 for two and $827,600 for one 48-in. line. Only one bidder named the same figure for Sabin and asphalt coated pipe but in one case, but the excess price of the others ranged from some 2 to 5%, except in one case, Gillespie Bros., where it was between 7 and 8%.

THE CHARACTER OF THE NEW YORK WATER supply has given rise to a discussion in the newspapers of late. It appears that the water has been carrying, at times, an unusual amount of sediment. This was made the subject of a long letter to the Department of Public Works by Prof. Chas. A. Doremus, in the course of which he is said to have recommended that the whole supply be filtered, and that an investigation be made "of the filter systems in use at Louisville, Ky., and Providence, R. I." In reply to this, Mr. Geo. W. Birdsall, Chief Engineer of the Croton Aqueduct, is reported as alleging that filtration has just been introduced at Providence, and so need not be considered, while at Louisville it has proved a failure. The facts are, that neither place has adopted filtration, but that Providence has conducted and Louisville is conducting exhaustive experiments. The Providence experiments related almost wholly to mechanical filtration, and the Louisville experiments wholly so. Mr. Birdsall urges that there have recently been an unusual number of freshets in the Croton drainage area, which are largely accountable for the condition of the water; also that filtration is out of the question for so large a supply and for the conditions which prevail in New York.

A TRACKLAYING RECORD was made May 23 on the Lima Northern R. R., between Napoleon and Wauseon, O., when Frank Grant, with 63 men, laid 6,480 ft. of track.

THE BRIDGE DISASTER AT VICTORIA, B. C.

The sudden and total collapse of a highway bridge span at Victoria, B. C., on May 26, resulting in the loss of about 55 lives, was recorded in our issue of May 28, and we are now enabled to give some further detailed particulars, together with views, as furnished us by several correspondents, including Mr. E. H. Warner, M. Am. Soc. C. E., of Seattle, Wash.; Mr. A. S. Going, Assoc. M. Am. Soc. C. E., of Victoria, B. C.; Mr. J. B. C. Lockwood, the Seattle agent of the San Francisco Bridge Co., and Mr. H. S. Wood, the engineer of the same company, now at the New York office.

FIG. 1.—SITE OF FALLEN SPAN OF POINT ELLICE BRIDGE AT VICTORIA, B. C.
(The Fallen Span was a Duplicate of the One Seen at the Right.)

The bridge was at Point Ellice, and carried the road to Esquimault across an arm of the bay. It consisted of two 120-ft. deck spans of Pratt combination trusses, 15 ft. deep, with panels 17 ft. 6 ins. long; two 150-ft. through spans of Whipple combination trusses, 25 ft. deep, with eight panels 18 ft. 9 ins. long; and a short trestle approach. It was one of the 150-ft. spans which gave way. The piers were pairs of iron cylinders, filled with concrete. The trusses were 20 ft. apart, c. to c., carrying a roadway 19 ft. wide in the clear, with felloe or wheel guards 3 × 6 ins. Two 5-ft. sidewalks were added after the bridge was commenced, each having three lines of 2 × 12-in. joists and 2 × 12-in. floor planks. The floor was about 20 ft. above the water.

The bridge was built in 1885 by the San Francisco Bridge Co., for ordinary highway traffic, and was classed by the builders as a country wagon bridge, no provision being made for its use by street cars. It was built for the Provincial Government, and turned over to the city of Victoria in 1891. The district beyond the bridge began to be built up, and in 1889 the Victoria Tramway Co. secured a franchise and laid a standard gage track across the bridge, using flat strap rails and spiking them to the floor planks, no extra stringers being put in. It does not appear that steps were taken at this time to ascertain whether the bridge would be overloaded by the increased rolling load due to the electric cars. In 1893, one of the floor beams broke as car No. 16 was crossing the bridge, and the track settled, but the motorman turned on the full current and got the car safely beyond the break. Steps were at once taken to have the bridge repaired, and we are informed that this work was done by a local carpenter and blacksmith. Five new floor beams were put in on each of the 150-ft. spans, these beams being 12 × 16 ins., while the old beams were 12 × 18 ins., and it was one of the old beams left in when the repairing was done that eventually caused the destruction of the bridge. At the same time new hangers 1¼ × 1¼ ins., with ends upset to 1⅝ ins., were put in for the new beams, the original hangers having been 1⅛ × 1⅛ ins. It is thought that this was done in view of the increased loading due to the cars, but as a matter of fact the old hangers show no signs of failure. The track was also relaid with 30 or 45-lb. T-rails, resting on two stringers, 10 × 12 ins., which took the place of two old floor joists, 3 × 12 ins., while two 3 × 12-in. joists were placed together midway between the track stringers. The stringers were in two-panel lengths, breaking joints on alternate floor beams. The floor itself was of 3-in. plank, laid diagonally, and nailed to ten lines of joists 3 × 12 ins. The floor-beams were bored near the ends for the tie-rods of the diagonal bracing, and notched for the nuts of these rods. The strain sheet shows that the structure was designed for a static load of 600 lbs. per ft., and a rolling load of 1,000 lbs. per ft. The ultimate tensile strength of iron was 50,000 lbs. per sq. in., and the working tensile strain 10,000 lbs. per sq. in., the factor of safety being 5 for iron and 6 for wood. The specifications on file in the Department of Lands & Works at Victoria require that the wrought iron in the main members should have an average ultimate resistance of 56,000 lbs. per sq. in., and should show a fibrous fracture. Cast iron must be of the best quality gray iron; chord bars must be weldless die-forged eyebars; and timber must be sound Douglas fir of best quality. In construction, however, the eyebars were made with welded ends, but this had nothing to do with the failure of the bridge.

The track was laid at one side of the roadway, the gage side of the inner rail being 2 ft. 7 ins. from the sides of the posts, or 5 ft. from center of truss to center of track. This was to reduce the bending strain on the floor beams, and in so far it was a good arrangement, but it actually increased the shearing strain, and it was this strain which ultimately led to the fracture of the rotten end of a floor beam, and the consequent destruction of the bridge.

The heaviest car owned by the street railway company was No. 16, a six-wheeled car with the Robinson radial two-wheel trucks, giving a total wheelbase of 14 ft. The body was 25 ft. long, and there was a 4 ft. platform at each end. The weight, empty, was about 16,000 lbs. and at the time of the accident the loaded weight was probably about 30,000 lbs., as at least 140 persons were on the car, although it had seating accommodation for only 60 passengers. According to our information, the manager of the street railway, acting under the advice of the city engineer, kept this car out of use last year, and only allowed one of the ordinary cars to be on the bridge at one time. Even with the ordinary cars, however, the bridge is said to have shown that it was not strong enough to carry the excessive loads thus imposed upon it, as shown by the evidence of persons who had crossed the bridge and rowed under it during its lifetime. There was a very heavy traffic on May 26, due to the day being a holiday in celebration of the Queen's birthday, and a great crowd was going over the bridge to see a sham fight and other attractions. In consequence of this traffic, car No. 16 was again put in service, and was packed full of people, as above noted. It was moving from left to right of the view shown in Fig. 1, approaching the second 150-ft. span, one end of which appears at the right of the cut.

The cause of the accident appears to have been as follows, as deduced from the expert investigation and from the evidences of witnesses at the coroner's inquest: When the car was over floor

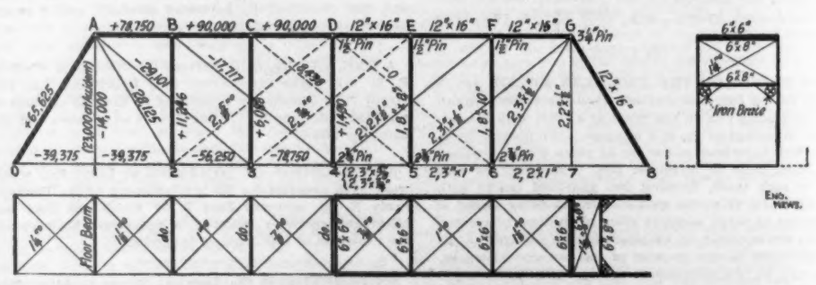


FIG. 2.—STRAIN SHEET OF POINT ELLICE BRIDGE.

The heaviest car owned by the street railway company was No. 16, a six-wheeled car with the Robinson radial two-wheel trucks, giving a total wheelbase of 14 ft. The body was 25 ft. long, and there was a 4 ft. platform at each end. The weight, empty, was about 16,000 lbs. and at the time of the accident the loaded weight was probably about 30,000 lbs., as at least 140 persons were on the car, although it had seating accommodation for only 60 passengers. According to our information, the manager of the street railway, acting under the advice of the city engineer, kept this car out of use last year, and only allowed one of the ordinary cars to be on the bridge at one time. Even with the ordinary cars, however, the bridge is said to have shown that it was not strong enough to carry the excessive loads thus imposed upon it, as shown by the evidence of persons who had crossed the bridge and rowed under it during its lifetime. There was a very heavy traffic on May 26, due to the day being a holiday in celebration of the Queen's birthday, and a great crowd was going over the bridge to see a sham fight and other attractions. In consequence of this traffic, car No. 16 was again put in service, and was packed full of people, as above noted. It was moving from left to right of the view shown in Fig. 1, approaching the second 150-ft. span, one end of which appears at the right of the cut.

The cause of the accident appears to have been as follows, as deduced from the expert investigation and from the evidences of witnesses at the coroner's inquest: When the car was over floor beam No. 3, Fig. 2 (one of the old original 12 × 18-in. beams), this beam sheared off at the end, the break being through the rotten wood at the hangers. This dropped the car about 18 ins., with the floor, and the car then ran on diagonally until it struck and knocked out the end vertical post 2-B, whereupon the entire span collapsed and dropped into the water. Incidentally the car broke the counter 2-D, while one of the eyebars 1-2 was broken in the fall. It is said that the span dropped straight down, canting slightly as it fell, but righting again on the bottom of the bay. The

ironwork removed is said to have shown itself to be of proper quality and strength, and even the timbers were probably strong enough, with the exception of one of the two old floor beams which had been in use, and had gradually rotted away radially from the holes for the hangers, where moisture was able to find an entrance. If all the beams had been renewed when five out of seven were renewed the accident would probably not have happened. Fig. 3 shows the condition of the beam at its broken section, while Fig. 4 shows the hanger that carried this beam, the nuts being in place, and the pin remaining in its shoe (marked 3 on the cut). The piece marked 2 is the seat of the end vertical post, and just above it, to the left, is the end of the broken chord bar 0-2.

The coroner's jury rendered a verdict holding the directors of the street railway company responsible for the loss of 55 lives. The City Council was arraigned as guilty of contributory negligence, and the officials of the corporation were absolved of personal responsibility.

RAILWAY YARDS AND TERMINALS.

By W. L. Derr.*

The fact that many railways fail to earn a fair return on their capital for lack of terminal facilities is so well known as to be practically an axiom. To some extent the engineer is responsible for this, because he has been prone to adopt the notion that the handling of the traffic at terminals is a matter of operation wholly, losing sight of the fact that the operating department can at best only make the proper use of such facilities as he has provided, and that no amount of operating skill can compensate for their deficiency in capacity or design. In general, it may be said that the location and arrangement of terminals should be as carefully considered as the location of the main line itself. This applies forcibly to lines even where quick movements are not of the greatest importance, and more forcibly to rapid transit lines, for upon prompt movements at terminals rather than upon high speed on the road depends the quickness of the service.

On new railways, the local operating conditions of which have not yet been developed, the arranging of the terminals devolves almost wholly on the engineer, and he should be in position to clear up any question concerning these, in view of their vital importance, before the money for them is required from the investors. On established lines, where the operating conditions have been developed, any extension of terminal facilities should, after careful consideration, be decided upon by the engineering, operating and traffic departments, acting together, whose conclusions, in the form of carefully drawn up memoranda, should be presented for the guidance of the engineer who is to design and have charge of the work.

To enable the engineer to so design a yard that it will give the best results from an operating standpoint, he should know the maximum length of incoming and of outgoing trains; the number of freight classifications to be made; the average number of cars per day, of each classification; the probabilities as to an early increase in any classification; the number of "station order" classifications to be made (i. e., classifications of local cars for the division in advance); whether provision is to be made for keeping fast and slow freight movements separated; the number, say, per week, of "hold" cars (i. e., loaded cars for points in advance and that are held for orders); the average number of cars per day for the local station at the point where the yard is located; the number of crippled cars to be provided for and whether they are all to be repaired at that point, and the maximum number of stored empty cars and of passenger equipment cars to be cared for. In the case of old lines these data are generally obtainable from the records, or can be fixed and agreed upon by the several departments interested. On new lines, however, they have to be thought out by the engineering department, and experience and good judgment are required to do it correctly.

The following general proposition may be stated as a fundamental principle in yard working: Cars that are to be held at a yard must be kept apart from those in the regular movement. The corrollary of this proposition is that separate tracks must be provided for the "hold" cars. To a violation of this principle, more plainly than to anything else, may be traced the delay to cars in yards, for, as will readily be seen, "hold" cars, when mixed in the regular movement, require a continual handling, having to be switched out every time the tracks they are on are worked. Yards otherwise poorly designed may often be operated in a fairly economical manner by providing storage tracks for the "hold" cars, both empty and loaded. It follows that, to secure order, separate tracks must be provided for cars of the different destinations.

All general movements of the traffic should be forward ones, and only under great stress are backward movements to be made. This point cannot be too firmly impressed upon those designing yards, as to neglect it will ever after cause great delay to the yard movements. Promptness in moving locomotives between the yard and the engine house is necessary, and the tracks should be so arranged that an incoming locomotive can, after placing its train on the receiving track, proceed immediately to the engine house. Where engines have to be changed quickly, as at division terminals in the case of the engines of

(*Superintendent of Delaware Division; Erie R. R.)

Fig. 3.—View of Fracture of Rotten Floor Beam at Hanger.

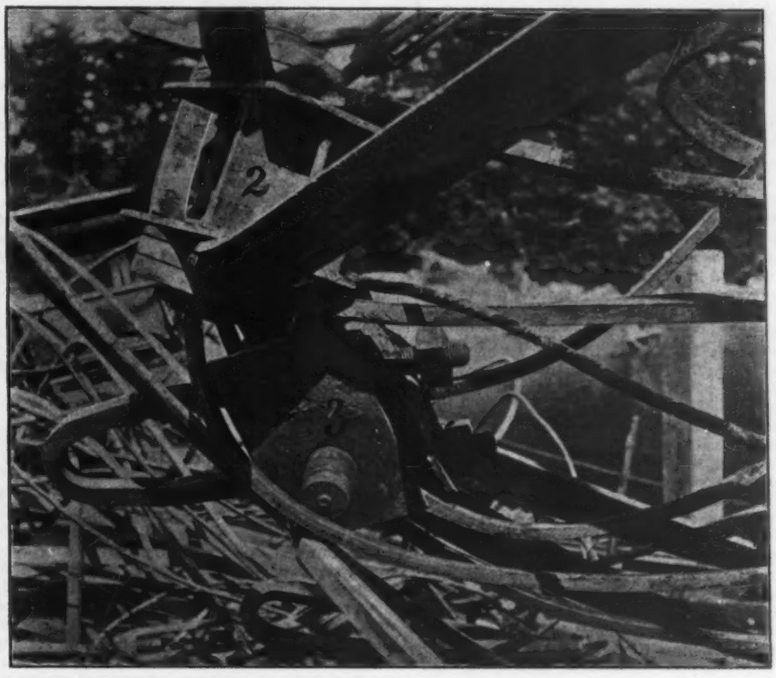


FIG. 4.—VIEW OF UNINJURED HANGER OF BROKEN FLOOR BEAM.

Extending from 2 to the right of the cut (and under the semicircular loop of cast iron) are the chord bars 2-3, below these again is the broken lateral rod, and at the bottom of the cut are the two counters 3-e, bent but not broken. The new hangers for the new beam had curved shoulders connecting the vertical legs with the loop for the pin, the shape resembling a gothic window, and being distinctly bad. Nevertheless these hangers do not appear to have contributed any cause of the accident. The timbers were of Oregon pine, and the metal work of wrought iron, and the strain sheet and the parts of the wreck appear to show conclusively that the bridge was properly designed for its purpose and was well built. It was, however, not properly inspected or maintained, nor was it properly strengthened for the extra loads imposed upon it by the street cars, which loads the bridge was never intended to carry. The shear on the broken beam is figured to have been over 1,500 lbs. per sq. in. of net section at the time of the accident.

Mr. John McMullen, formerly President of the San Francisco Bridge Co., has stated that in 1891 he visited Victoria, and on seeing the cars that were being run over the bridge, he warned ex-Surveyor General Gore of the danger, but was told, as he recollects, that the engineer of the street railway company had examined into the matter and was satisfied that the bridge was safe. In 1889, the Albion Iron Works wanted to take a heavy load across to the navy yard at Esquimault, and on applying to the city authorities was told that it could only be done at the company's own risk. The company had the bridge examined by its engineer and then hauled the load over in safety.

passenger trains, a track should be placed near the changing point, for the accommodation of the incoming and outgoing engines. The coaling station, ash pits, sand house and water supply should be near the round house, and be accessible at all times.

A freight yard, of which a typical arrangement is shown in Fig. 1, should have receiving tracks of the length, each, of the longest incoming train, for the reception of the trains as they arrive at the yard; "poling" tracks, if the poling method of switching cars is practiced (where there is not sufficient length of yard for poling tracks the "poling" can be done direct from the receiving tracks); classification tracks—one for each classification; advance tracks to receive cars taken from classification tracks, and upon which trains are to be made ready to be sent forward; short tracks, commonly called a "gridiron," holding from five to ten cars each, and used in classifying cars in station order for the division in advance; tracks for storing empty cars; tracks for "cripple" or damaged cars, and tracks for cars with fast freight. "Poling" and classification tracks may be of any convenient lengths. For poling tracks this would be about the length of an incoming train. For the shortest classification track, in order that switching may be continued during a temporary blockade of the main line in advance, it would be a sufficient length to hold the cars of that classification of several hours' working. Where there are advance tracks the classification tracks may be somewhat shortened, but it must be borne in mind that the filling of one classification track blocks the classification of cars on all the others until the filled track is relieved. Very long yard tracks are not desirable for several reasons, among which are the high speed required to pass cars to the extreme ends of such tracks (especially if the switching is done against a rising grade), and the great delay and consequent expense in returning the men to the switch engine after they have taken cars long distances. Separate tracks for stored empty cars should be provided in order to keep these cars out of the regular yard movement, which they would otherwise greatly complicate.

A perplexing question in yard operation is how to keep the cars with fast freight separated from those with slow freight. If both are handled on the same classification tracks, they will become mixed, causing serious delay to the fast freight. To handle the latter advantageously, tracks should be provided for its exclusive use. These may be either separate tracks next to the main track in the classification or in the advance portion of the yard, or, better, a set of tracks in advance of all the other tracks, so that the fast freight will always be ahead of the slower. The care of disabled or "crippled" cars must be provided for, and the faster the traffic the greater the necessity for facilities for the prompt handling of these cars.

Perhaps no detail of yard design is more troublesome than that of providing for the prompt movement of cabooses, or cabin cars. The tracks for these cars should be so located that the cabooses can be got out of the way quickly on their arrival at the yard and yet will be accessible, without undue handling, to outgoing trains; and, if practicable, as soon as these cars arrive at the yard arrangements should be made to so place them. When there is room for it, a loop caboose track reaching from the receiving tracks, incoming, to the advance tracks, outgoing, will be found to be a convenient arrangement. When certain trains are run regularly by one set of crews and others by another it will facilitate matters to keep the two sets of cabooses separate, by providing a double caboose track.

Heavy track scales should be placed at the entrance to the classification tracks, so that cars can be weighed while being switched. They should have a separate "dead" track, permitting cars that are not to be weighed to be passed over without affecting the scales. The location of scales for local purposes will, of course, be governed by local requirements.

The location of the yard with reference to the main tracks is an important matter. The yard may be placed on the outside of each main track, or to one side of both the tracks, or between them. The first plan is objectionable on account of the necessity of crossing the main tracks in passing from one side of the yard to the other; and the second on account of the traffic in one direction crossing the other main track to get into the yard. The third plan, that of placing the yard between the main tracks, is open to neither of these objections, and, if it further provides for the sufficient separation of the main tracks to make room for the engine house as well, the yard movements will not foul the main tracks from the time the trains leave the main tracks when entering the yard until they come on them again when leaving the yard. Main tracks so located should, when practicable, be placed far enough from the yard tracks to admit of additional tracks being built in the space, as required. At points where there are yard connections with main track the connections may be so arranged that ordinary switching movements will not cause the main track to be fouled when the switch is set for the main track movements. This may be effected by connecting the main track and the first yard track with a crossover and extending the yard track a short distance beyond the crossover, thus forming a "run by."

At points where there are two or more roads maintaining separate yards, connecting tracks should be provided for the interchange of business between the different lines. Separate tracks for the receipt and delivery of cars are convenient, and the capacity of these tracks will depend, naturally, upon the amount of business interchanged. Where the yards are some distance apart it is desirable to have sufficient room on the connecting tracks to accommodate a day's business, this being a special advantage in the event of the receiving line being temporarily blockaded.

Tracks for cars to be loaded or unloaded by teams should be at least 24 ft. apart, c. to c., so that the teams can pass freely between the lines of cars and be clear of the cars when the same are being moved. Where space sufficient for teams to turn cannot be had between tracks, it should be reserved at the extreme ends of the tracks. At points where live stock is loaded or unloaded, cattle pens should be placed alongside separate tracks accessible to outgoing or incoming trains, as the case may be, so that prompt movement can be given this traffic. Stock shipments require quick handling, both in yards and on the road, and everything pertaining to their dispatch as well as to the comfort of the animals should be considered. The pens should have inclined chutes (the rise to be about 1 in 4) reaching from the ground to the floor of the car. For hogs, sheep and other small stock, loaded in "double deck" cars, double chutes are required, to correspond with the two floors of the cars.

Passenger, baggage and mail cars should not be put in the yard with freight cars, as it is necessary to keep them near the passenger station, so that they will be available at all times and on short notice.

The plan shown in Fig. 1 does not represent any actual yard, but represents a typical plan showing the principles to be aimed at in the general design of any large yard, and the following is a brief explanation of the method in which it is operated:

A train containing ordinary or slow freight only, on arriving at the yard is placed on the receiving tracks by the road engine, which then goes, by way of the inbound engine track leading from the receiving track, to the coaling station and thence to the engine house. If the train contains fast freight only (which usually requires but little switching), it is placed on a fast freight track, after which the engine proceeds to the coaling station and the engine house, using the in-bound engine track leading from the fast freight tracks. If the train contains both classes of freight they are placed on their respective tracks as above. The caboose is detached from the train and run into the caboose switch. After the "repair" cars are switched out and set on the repair tracks, the slow freight on the receiving tracks is placed on the poling tracks, whence it is switched to the classification tracks, such cars as require it being weighed while passing over the scale track. Repaired cars are taken back to the receiving tracks. When the classification tracks are filled, the cars thereon are taken to the advance tracks, or are at once made up into trains and then taken to the advance tracks, from which through outbound slow freight trains are dispatched. Fast freight trains are started from the fast freight tracks. Loaded "hold" cars are placed on advance tracks provided for their exclusive use. Cars to be iced, which are usually in fast freight trains, are placed at the ice house promptly on their arrival. Cars for local stations of the division next in advance may be first indiscriminately assigned to classification tracks and afterwards redistributed on the local order tracks, and thence taken to the advance tracks. Outbound engines proceed from the engine house to the advance tracks or fast freight tracks by the outbound engine track. All outbound trains in one direction take on their cabooses at the same point. Stored empty cars are taken direct to the empty car storage tracks. The coal for the local coaling station generally comes from one direction, and may be first placed on the nearest supply coal track, and then be taken as required to the other station. Local freight trains leave their through cars on the receiving tracks and take any cars they may have for the station direct to the freight house. Extra passenger equipment is kept on the tracks provided for that purpose at the passenger station, which are also used by passenger engines while waiting the arrival of their trains.

The track from which a series of parallel tracks start is called a "lead," or "ladder" track (Fig. 2). This track is, generally speaking,

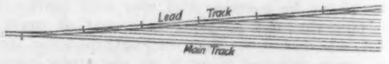


Fig. 2.—Ladder Track for Yard Switching.

at an angle to the parallel tracks equal to the angle of the frogs. When it is necessary to divide a series of parallel tracks without breaking their continuity, a straight lead track with "slip switches" (Fig. 3), is run diagonally across them,

Fig. 3.—Slip Switches in Ladder Track.

the crossing of the tracks being effected by means of crossing frogs. A short curved track with a switch at each end forms the connection between the lead and the track it crosses. The outside rail of the curve of the connecting track lies within

the diamond shaped space formed by the two tracks crossing each other, and the inside rail lies without this space. Where there is a large number of tracks, such as classification tracks, it may be advisable to make the entering end of the set wedge shaped in order to concentrate the switches and also to lessen the wear of the frogs and switches by trains crossing them. For the prompt operation of lead switches the levers for throwing them should be grouped, so that they can be worked by one attendant from a central station. This is not only the quickest but the safest method of operating the switches, because it avoids such misunderstanding as is apt to ensue if more persons than one handle a set of switches. The levers need not necessarily be interlocked. The switch lights are placed on stands near the points of the switches they govern and are turned by the movement of the switch rails. The lamps are provided with lenses of two colors indicating, respectively, that the switch is set for the lead and for the side track. Switch lamps should be placed close to the ground, so that they will not conflict with any block or interlocking signal in their neighborhood.

Poling and Tail Switching.—There are two methods of sorting cars; namely, "poling" and "tail switching." In the first method, a pole attached to the switch engine itself or to a "poling car" is guided to the side or end of the car to be handled, and the switch engine with a quick start sends the car on to its proper track. The "poling car," on account of the feasibility of using any engine with it, is superior to the "poling engine." The cars to be poled are placed on the "poling track," and each "cut" or set of cars is uncoupled in its turn. On the front end of the head car of each cut is marked in chalk the number of the track on which the "cut" is to go. On the rear car of the "cut" is marked, for the information of the switch thrower, the number of the track for the next "cut." In "tail switching" the cars to be sorted are coupled ahead of the switch engine, and one cut at a time is uncoupled. The whole "string" is given a quick start ahead, and is suddenly stopped, all but the uncoupled cut, which runs on to the proper classification track. In either method of switching a man accompanies each "cut" to the classification track.

Switching at Passenger Terminals.—Where tail switching is operated as at passenger terminals, the tracks should be so arranged that the engines of incoming trains can be relieved promptly on their arrival at the station. Obviously, these engines cannot be moved until the cars they brought in have been hauled back out of the way. A series of leads or crossovers should be placed just outside the train shed, to afford passage from one track to another. Tracks should also be provided nearby for the temporary storage of passenger equipment that is not needed at the time. The trainshed should contain more tracks than are actually required for starting trains from, so that cars may at all times be transferred from one track to another, not only to relieve engines, but also to admit of trains being made up in outgoing order without having their cars taken away from the station.

Electric Communication.—Prompt means of communication between the train dispatcher's office, engine house, yard offices, and block stations should be provided. The telegraph and telephone are generally used for this purpose. Electric bells, also, may be used. The telephone lines should have continuous, or metallic, circuits, and the wires should be placed as far as possible from electric light wires to avoid annoyance from induction. Much prompt signaling can be done by electric bells operated under a prearranged code, by which a few strokes of the bell will convey a whole order or complete information of a move.

Lighting Yards.—Electric lighting is the best for yard illumination, provided the lights are located with care. Electric lights cast a deep shadow, and unless they are located high over the tracks the shadows of cars and buildings near by will be troublesome. They should never be placed near an important signal, as their strong light obscures the weaker light of the signal. Electric lights make the best switch lights, also, giving a much stronger light than oil and requiring less attention in their care and maintenance.

Signaling.—The principles of signaling are the same in yards as on the line. At the entrance to the yard the main track switches should be operated from a central station and be interlocked with the signals that govern the main track movements and movements that may foul the main track.

Coaling Stations.—The ordinary gravity coaling station, such as is used in the anthracite coal regions, where it has proved a commercial success, gives good results in railway operation. It consists of a heavy trestle, with an inclined approach, surmounted by an elevated platform carrying tracks upon which cars of coal are placed for unloading into bins which are situated under the platform between the trestle bents, and whose bottom edges are placed high enough to clear the highest engine tank. The space between the ground and the under sides of the bins may be utilized for storing coal. There may be a double track on the trestle with a crossover at the further end, so that the empty cars can be taken off the trestle without disturbing the loaded cars. The cars may be placed on the trestle by locomotives direct, by a stationary hoisting engine and cable, or by a locomotive hoist. In the latter case a cable is passed up the incline and along to the extreme end of the trestle, thence over a heavy pulley placed at about the level of the tracks of the trestle, thence by a pulley near the ground to the place of coupling with the locomotive, which travels along a track parallel to and alongside the trestle. There should be two tracks below the coal station with crossover connections between, enabling an engine that has been coaled to leave without interfering with other engines at the pockets.

Ash Pits.—These should be so arranged that cars for receiving the ashes can be run directly beneath them. The platform on which the ashes are dumped should be provided with dumping hatches, so that the ashes, after being cooled, can be dropped directly into the ash cars. Where this construction is impracticable the track for the ash cars should be placed alongside the platform, but depressed the height of the cars below it. For cleaning the ash pans water under pressure and good drainage facilities should be provided.

Sand House.—The sand house should be equipped with furnaces for drying the sand and keeping it dry, power lifts for elevating it, bins for storing it and spouts for passing it to the locomotives.

Water Supply.—Water cranes should be located at the engine house, at points where switch engines work, at coal pockets (if distant from the engine house), and at the outgoing ends of the yard. A main with hydrants about every 200 ft. should be placed along the receiving tracks for the use of car inspectors in cooling journals, and in other work. Incidentally it might be added that there should be fire hydrants near important buildings and at points where cars are stored.

Yard Buildings.—These consist of an engine house, ice house, yard offices, car inspectors' stations, signal stations, and a building for the use of trainmen while waiting for their trains. The engine house is usually of a permanent character, brick and metal being mainly used in its construction, but wood is preferable for the other buildings, as it is sometimes necessary to move these on account of changes in tracks. Special attention should be given to the construction of the foundations of buildings placed near tracks, particularly if on newly made ground, as such buildings are subjected to much vibration on account of passing trains. Standard clocks, from which trainmen take official time, are likely to be damaged if placed in buildings in which there is much vibration, unless preventive measures are taken, such as providing piers, for supporting the clocks, set on foundations separate from those of the buildings and carried down into the ground to a solid bearing, care being taken to keep the piers clear of any floors through which they may pass, and away from the walls of the buildings. Wooden bins for holding a supply of links and pins should be placed at convenient points in the yard. For icing meat, fruit, vegetables, etc., in transit, icing stations are required at all division terminals. As this class of freight is usually handled in fast freight trains an ice house should be located near the outgoing end of the fast freight tracks on a separate track, accessible alike to incoming and outgoing trains, and so arranged that the road engine bringing the train into the yard can take the cars to be iced to the icing station, and the outgoing train take them on there.

Rapid Transit Terminals.—Rapid transit in large cities requires very frequent passenger train service at comparatively high speed. From the traffic not being a mixed one, the forwarding of it is simplified, but this gain is, ordinarily, more than offset by the complications involved in keeping up the required constant movement at regular intervals. On rapid transit lines the interval between trains, that is the "headway," is largely dependent on the arrangement of the terminal tracks. As a general proposition it may be stated, concerning such lines, that the time required for a train to pass through a terminal should be no greater than that required for it to pass over any equal length of the line. In other words, in practice trains cannot be run on a headway less than the time used by a train in entering and leaving a terminal. From this the deduction is made that

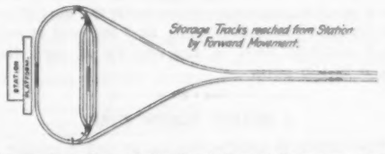


Fig. 4.—Loop Terminal for Rapid Transit Railways (Storage Tracks Reached From Station by Forward Movement.)

the arranging of the trains for the outward trip should not necessitate their stopping at the terminals for this purpose. Any arrangement of track that makes it necessary to stop a train for the purpose of putting it in proper order as to engine or cars, or of putting it on the proper track for the outgoing trip, or that permits an incoming engine to be blocked in and thus necessitates an exchanging of engines, is defective, so far as the running of trains at short intervals is concerned. Quick movements can best be made by arranging for the forward movement of the trains in all cases, and avoiding the necessity of having the traffic in one direction cross the traffic in the other direction.

The "loop" plan of track, shown in Figs. 4 and 5, is the only one that fulfils the desired conditions. The loop, which is simply a circular track connecting the incoming and outgoing tracks,

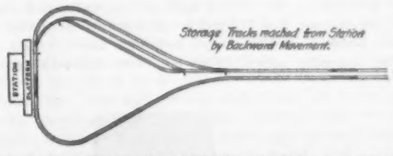


Fig. 5.—Loop Terminal for Rapid Transit Railways (Storage Tracks Reached from Station by Backward Movement).

forms a continuous track to permit trains to pass from an incoming to an outgoing track by direct forward movement. No change in the arrangement of the train is necessary, and the locomotive is always run in the forward motion. By any other plan it is necessary either to run the engine backward (thus placing the engineman on the off side, away from stations and signals), during one-half its entire mileage, or else to turn the engine at the end of each run. In addition to the main line loop a sufficient number of tracks should be provided along it, or, at least, not far from it, for the purpose of storing the engines and cars which it is necessary to keep at the terminal. These additional tracks should be connected at both ends with the main track. Their exit ends should be far enough back of the starting station to make it unnecessary for a train, after pulling out, to back up in order to reach the station. Fig. 5 is, perhaps, the ideal loop track for this purpose, no backward movement being necessary in handling the ordinary traffic, either in passing from the main track to the side track or in returning to the main track from the side track.

The terminal buildings of rapid transit lines

are placed outside the loop, preferably, so that they will not obstruct the view ahead, and, on account of the resistance offered by curvature of track to the starting of trains, the station buildings should not be placed along the curves of the loop. At points where there is not room for a loop, space should be reserved for terminal tracks of the usual order. If the room is so limited that even these cannot be accommodated, a trailing crossover should connect the two main tracks about an engine length from the end of the incoming track, so that an arriving engine can get out of the way without having to move against incoming trains or without having to wait for the train that it brought to be taken away. There should be another crossover a train length farther back to admit of the passage of trains from the incoming to the outgoing track.

Cost of Yard Work.—Items which make up the cost of yard operation are, besides interest on capital invested and depreciation, the cost of yard engine repairs and supplies, wages of yard enginemen, yard firemen, switchmen, yardmasters, signalmen, telegraph operators, way bill clerks and of trackmen; a percentage of general office expenses and of wages of train dispatchers, the cost of material used in track repairs, and the cost of labor and material used in the repairs of cars damaged in the yard.

A ROTARY SCREW PUMP.

This pump is unique among pressure pumps in that it has no valves, no internal packing, and no pulsation in the delivery pipes. Four screws,

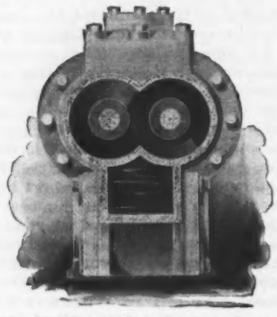


Fig. 2.—Cross Section of Rotary Screw Pump Through Cylinder and Screws.

mounted in pairs on parallel shafts, act as pistons in propelling the liquid and are so arranged that in each pair the thread of one screw projects to the bottom of the space between the threads of the opposite screw (Fig. 2). The threads are of such a shape that this intermeshing portion completely locks off from each other the spaces between adjoining convolutions of the threads of each screw, with the result that any material engaged by the screws at one end is forced positively along the cylinder to the other end of the screws. Space enough is left between the faces of the intermeshing threads and between the exterior of the threads and the cylinder to allow a close running fit without actual contact. The screws have no end thrusts in their bearings, because they receive the back pressure of the column of liquid in two opposite directions, so that the endwise pressure against the screws in one direction is counterbalanced by a like pressure in the reverse direction.

The suction connection at S (Fig. 1) opens into a chamber underneath the pump cylinder. The liquid as it is drawn in passes through this chamber into the two opposite ends of the cylinder, from which points it is forced toward the center by the two pairs of intermeshing threads. The discharge is from the middle of the top of the cylinder, as shown. Power to drive the pump is applied directly to one of the shafts, the second shaft being driven by means of a pair of gears shown at G (Fig. 1). The only packing is in the stuffing boxes where the two shafts pass through the cylinder heads. As these stuffing boxes are on the suction end of the pump, there is no tendency to blow out the packing. The action of the screws on the liquid pumped is continuous, and the delivery is smooth and uniform. The absence of pulsation increases the efficiency of the pump by reducing the pipe friction and makes the pump peculiarly suitable for certain special purposes. In pumping liquid into filter presses having metal screens any pulsation tends to very much shorten the life of the screen, and the same thing is true where sprinkling water is thrown on the wire of a paper machine. In handling oil, particularly petroleum oils, the absence of any pulsation in the flow of the oil through pipes very greatly diminishes the difficulty of keeping the pipe joints tight. In these cases, and in others where the pulsating delivery of a reciprocating pump is objectionable because of its noise, this pump has been successfully applied. As a rotary pump, running at high speed, it is used in direct-connected electric work, particularly for hydro-electric elevator service. It is in successful use on the pressure tank system, the roof tank or gravity system, and for pumping directly into the elevator cylinder. In this last method of application, the absolute absence of pulsation makes it possible to pump directly into the elevator cylinder and still maintain a perfectly smooth motion of the car. The effect of the direct connection is that the pressure against which the pump has to work varies with the load in the car, and as the average load is less than half the maximum load a material economy of operation is obtained. For all ordinary elevator pressures it is claimed to give an efficiency of 50%, or better, from the wire to the water. Even better results are obtained when the pump and motor are designed for work against some particular pressure that does not vary more than 10 or 15 lbs.

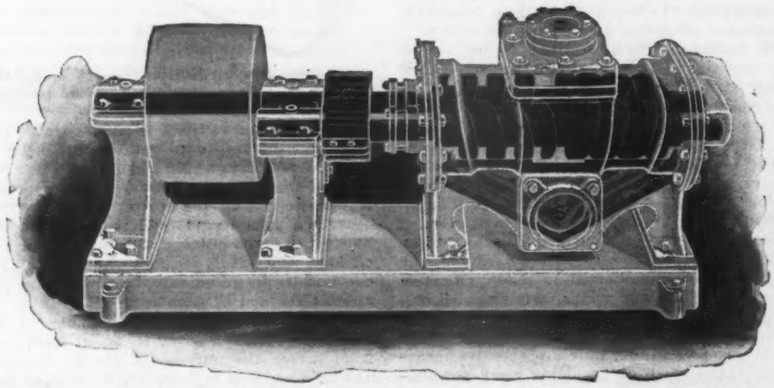


FIG. 1.—PERSPECTIVE VIEW OF ROTARY SCREW PUMP, WITH STATIONARY PARTS TRANSPARENT TO SHOW INTERMESHING OF THREADS.

Wm. E. Quimby, 39 Liberty St., New York, Inventor and Manufacturer.

The pump was originally designed for handling syrup and other thick liquids, the absence of valves and the steady continuity of its delivery making it especially suitable for such work. The pumps have been in use for such purposes for nearly four years. The ability to handle thick liquids and the freedom from pulsation make it suitable for pumping paper stock up to the feed-box of a paper machine, and for pumping thick liquids where any pulsation would have a churning and consequently detrimental effect.

One of the earliest applications of the pump to elevator work was at the furniture warehouse of Webster, Cooke & Co., No. 1 Washington St., Boston, where the pump delivers the water directly to the elevator cylinder. The Hotel Clunay in Boston has the pump operating its elevators by means of the pressure tank system, and at 28 Union Square East, New York, can be seen an application to the roof tank or gravity system.

There are other more recent applications to which reference can be had by applying to the manufacturer, William E. Quimby, 39 Liberty St., New York.

ECONOMY IN CAR LIGHTING.

By H. K. Landis.

Nowhere is the popular demand for personal comfort so apparent as in modern railway practice, and particularly is this the case in first-class car service in the United States. Nowhere in the world has it been equalled, conforming to the demands of its patrons who are willing to pay for what they get, until a journey across the continent is almost a pleasure. Though ventilation can be improved upon, lighting is quite satisfactory; we have emerged from tallow dips and kerosene lamps and have now a light one can read by as easily as in his own home. A year or more ago several important railway companies determined to investigate for themselves the relative economy of the various forms of illuminating gas and burners for passenger coaches. Pintsch gas made from petroleum, and ordinary city illuminating gas held the field, both being satisfactory, but their relative economy and cost had never been accurately determined; but "when hard times came a knocking at the door" of our railways, and the shaving of expenses proceeded from one department to the other, the car lighting department came under investigation. Dr. Love made some comparative candle power tests a year since which corresponded very closely with those made by Profs. Chandler and Denton somewhat later for the Lehigh Valley R. R., and which were published in the technical press a little over six months ago. The Pennsylvania R. R. has also been investigating the question, and a report by Prof. C. F. Chandler, of Columbia College, and Prof. Denton, of Stevens Institute, may be expected to appear very soon. The candle-power tests made for the Lehigh Valley R. R. were followed by others which were to determine the relative cost of the two systems, and which have been embodied in a report made by Prof. W. H. Chandler, of Lehigh University, and Prof. Denton embracing 44 typewritten pages of detailed information. A feature of this, as also of their former report, is that all data used, the methods employed and the calculations necessary are given in detail, as are also the observations, so that there is no trouble in checking the work by that done by others. The report cannot here be produced in full, but those interested are advised to secure it. The report is on the "Relative Cost of the Use of City Gas and Pintsch Gas, Respectively, for Supplying the Lehigh Valley Passenger Car Service at Easton with an Equal Amount of Illumination, the Pintsch Gas being Used in Either the Pintsch Argand or the Pintsch Four-Flat-Flame Lamp, and the City Gas in the Gordon-Mitchell Lamp."

The report states that the Pintsch Co. proposes to furnish the generating and compressing plant, operate it and deliver Pintsch gas at the car cylinders for $5.00 per 1,000 cu. ft. in the cars. Pintsch gas burns at the rate of 3.4 cu. ft. per hour in either the Argand or four-flame lamp. The service at Easton on 80 coaches per day requires 18,872 cu. ft. of city gas per 24 hours, thus the Pintsch gas equivalent of city gas burning 7.6 cu. ft. per hour will be $18{,}872 \times \frac{3.4}{7.6} =$ 8,443 cu. ft. per 24 hours. The Pintsch Argand lamp gives out 54 c. p., and the four-flat-flame Pintsch lamp about 37 c.p. at an angle of 45° from the vertical. It was found that both gases varied widely in candle power. Actual tests showed in

extreme cases a loss in city gas of 54.2% of the candle power in compressing to 17 atmospheres, while Pintsch gas has lost as high as 4.4% bn compression to 12 atmospheres.

After calculating the cost of coal, water, repairs, interest and depreciation, labor, cost of gas, etc., they say: "Our conclusions regarding the cost of the use of city gas calculated at 270 lbs. pressure compared to that of Pintsch gas at 177 lbs. are embodied in the following table:

SUMMARY of Annual Cost of Using Different Lamps for a Car Service, which Consumes 6,190,525 cu. ft. of Jersey City Gas per Annum in Gordon-Mitchell Lamps Using 7.6 cu. ft. of Gas per Hour.
Cost of Gas Consumed: Jersey City, $2.883 per M.; Pintsch, $5.09 per M.

Kind of lamp.	Kind of gas.	Gas consumed per hour. cu.ft.	Gas consumed per annum. cu. ft.	C. p. at 45° from vertical.	Annual cost of gas.
Gordon-Mitchell lamp.	Jersey City	7.6	6,199,525	29	$17,873
Pintsch Argand "	" "	7.13	5,815,254	30	16,765
Pintsch Argand "	Pintsch*...	3.41	2,781,829	54	14,158
Gordon-Mitchell "	" ..	3.36	2,823,353	26	13,964
Pintsch 4-flat flame...	" ..	3.31	2,702,903	35	13,758
Pintsch 4-flat flame...	" ..	2.79	2,275,879	29	11,558

* From the D., L. & W. R. R.

Aside from these general deductions, there are a number of points brought out of value to a railway man.

Compression Plant. — Leakage. — Though there was no loss in compressing air up to 20 atmospheres, city gas lost 6.6% in volume due to liquefaction under pressure amounting to 3.2 lbs. per 1,000 cu. ft. of gas. Pintsch gas, compressed to 14 atmospheres decreased 14% in volume with 8.72 lbs. liquid deposit per 1,000 cu. ft. of gas compressed; between the compressor and the car there was a loss of 28%, due principally to poor connections and porous hose; these figures were derived from a plant charging 100 cars per day for 5 years; there was, therefore, a net leakage from the hose in filling reservoirs of $28 - 14 = 14\%$ with Pintsch gas. The experts, therefore, allow also 14% for leakage of city gas which, added to the 6.6% compression loss makes a total of 20% for city gas, and the total quantity required in this case would be $\frac{18,872}{0.8} = 23,590$ cu. ft.

Compressors.—It was found most economical to compress by two stages and best to have a high pressure storage reservoir to be pumped from in cases of excessive demand as sometimes happens in the forenoon; at any rate two compressors each with 2,500 cu. ft. per hour displacement are recommended. The compressor plant is estimated to cost $2,094 complete.

Power Required.—To compress gas from a storage reservoir from street main pressure up to 20 atmospheres at the rate of 2,500 cu. ft. per hour, 14.25 I. HP. are estimated as being necessary, requiring 45 lbs. of water per horse-power hour, or a total of 641 lbs. of steam at 60 lbs. pressure per hour; this corresponds to about a 22 HP. (commercial rating) boiler having about 300 sq. ft. heating surface and 10 sq. ft. grate surface. This boiler plant ready to operate will cost $550.

Capacity of Reservoirs.—The specification is that the Buffalo night express, consisting of 3 day coaches and 2 sleepers shall be charged with gas in about 10 minutes without interrupting the regular charging service. Three coaches having five lamps to a coach each burning 12 hours at 7.6 cu. ft. per hour consumption, will burn 1,368 cu. ft. of gas. Two sleepers with ten lamps each burning six hours full consumption and six hours half consumption will burn also 1,368 cu. ft. gas or a total for the train of 2,736 cu. ft. Suppose, while this train is charging, there is a three coach train having its 18.6 cu. ft. reservoirs ¾ exhausted, being charged in the yard, in half an hour. The gas required in half an hour at 270 lbs. would then be 776 cu. ft. making a total of $2,736 \times 776 = 3,512$ cu. ft.; the compressor supplies 1,000 cu. ft. in that time, so the reservoir must supply 2,512 cu. ft., as the pressure falls from 300 lbs. to 270 lbs.; this will require an aggregate capacity of 1,256 cu. ft., or five reservoirs 50 ins. in diameter and 20 ft. long, costing $4,000. or a total cost for reservoir plant of $5,650. The pipe lines will cost $2,972. The 18.6 cu. ft. gas tanks on the 5-lamp day coaches, stored with Pintsch gas at 177 lbs. pressure, will be exhausted in 14 hours, while city gas at 270 lbs. pressure would burn but 9 hours; to increase this 9-hour capacity to 14 hours will require an extra tank capacity of 10.4 cu. ft., which will cost $55 per car, with 15% reserve gas.

Cost of Plant.—The total investment, therefore, for an instalment furnishing the stated quantity of city gas will be:

Compressor, buildings and foundation for same.	$2,094
Boiler erected and housed	550
Storage reservoirs, erected and housed	5,050
Pipe line and charging fittings in place	2,972
Cost of additional car tanks for 14 hours' burning	9,570
Total investment	$20,836

Operating Expenses.—For furnishing 18,872 cu. ft. of city gas per 24 hours in winter and 80% of this in summer, allowing 20% leakage. The expenses will be about as follows in cents per 1,000 cu. ft:

	—Steam plant— Included.	Excluded.
Coal, at $1.75 per gross ton	$4.25	$4.25
Water, at $1.00 per 1,000 cu. ft.	1.19	1.19
Labor, engineer and fireman	21.46	19.37
Labor, carfillers	27.90	27.90
Material for repairs of charging system	14.40	14.40
Interest and depreciation	34.06	33.15
Cost Jersey City or equivalent gas used	188.00	188.00
Total operating expenses per M used.	$2.9130	$2.8830

General Conclusions. — The report continues: "The cost of obtaining the required illumination from the Pintsch lamps will be $5.09 per 1,000; and from the Gordon-Mitchell lamps with city gas (requiring 3.93 times as much gas for equal illumination) $2.883 \times 3.93 = \$11.33$. In other words, the Pintsch gas might be sold at $11.33 and be as cheap per unit of illumination as the city gas at its cost of $2.883 per M. stored on the cars. In view of the large difference in candle power of the two lamps, however, equal illumination could not be afforded by them in a car unless there were nine Gordon-Mitchell lamps to about five Pintsch lamps. Such a difference in the number of lamps is, of course, impracticable, so that the use of the Pintsch Argand lamps with Pintsch gas must be accompanied with greater illumination in the car than is obtained from an equal number of Gordon-Mitchell lamps and city gas as employed in the experiments."

Cost Per Car-Hour.—Using five Pintsch Argand lamps, which burn 3.41 cu. ft. per hour of Pintsch gas, giving out 54 c. p. at 45°, at $5.09 per M. the cost will be 8.7 cts. per car per hour. Using the same number of Gordon-Mitchell lamps of 29 c. p. each at 45° with city gas at $2.883 per M. and allowing 20% leakage, we have 11.0 cts. per car per hour. "Therefore, the use of the Pintsch Argand system costs for gas about 20% less per car hour than the Gordon-Mitchell system, and affords about 70% more illumination below the horizontal."

Though the advantage of the former system seems great the following data is what the railroad manager is most interested in:

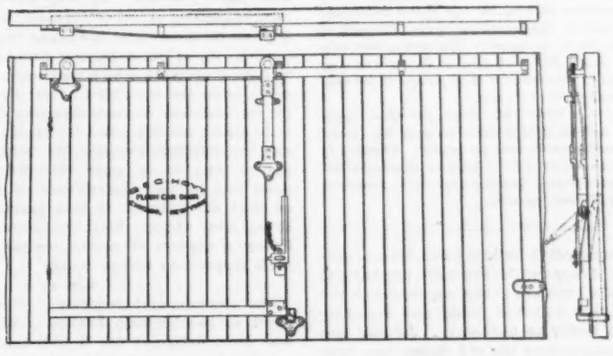
Relative Economy.—The Gordon-Mitchell lamp, of 29 c. p. at 45°, using 7.6 cu. ft. of city gas per hour, would consume 6,199,585 cu. ft. per annum, costing $17,873. The Pintsch four-flat-flame lamp, consuming 3.31 cu. ft. per hour, giving out 35.4 c. p., burning Pintsch gas to the amount of 2,700,056 cu. ft. annually, will cost for gas $13,743, thus saving $4,130 per annum, with more illumination. For equal illumination there will be a saving of $6,370.

The Pintsch Argand lamp uses 93.8% of the value of city gas consumed by the Gordon-Mitchell lamp, and would, therefore burn $16,765 worth of city gas. The Gordon-Mitchell lamp burning Pintsch gas at the rate of 3.36 cu. ft. per hour consumes 1,015 times the amount used in the Pintsch four-flat-flame lamp or $13,949 of gas with but 74% of the illumination.

It is, therefore, seen that the proposition made by the Pintsch Compressing Co. is by far the most economical. "The candle power afforded by five Pintsch Argand lamps is practically equivalent to that furnished in cars lighted by 16 incandescent electric lamps," which is a larger amount of light than has been generally used on electric lighted trains in this country. The railway managers who experiment with electric lighting, therefore, must do so for some other reason than the desire to obtain better light or to save in the cost of service, electric train lighting being notoriously expensive.

A FLUSH FITTING DOOR FOR FREIGHT CARS.

The Hoyt car door, shown in the accompanying cut, fits flush with the side of the car when closed, and is hung entirely from the top, no bottom rail being used, but only a sliding guide bracket and a catch which falls back into a recess as the door is closed. Above the doorway is the track rail, supported by brackets, and on this run the wheels of the hangers attached to the door. The rail is inclined inwards at the meeting post of the door, as shown by the plan. The locking device at the rear end of the door is operated by a lever which throws the door back into its place between the posts, the leverage being sufficient to force a badly sprung door to close tightly. The door cannot be unlocked without breaking the car seal. The door is claimed to be storm-proof, and to be cheap in first cost and in maintenance. It is being put on the market by the Q. & C. Co., of Chicago and New York.



THE HOYT DOOR FOR FREIGHT CARS.

LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Fixing Rates of Water Companies.

A city, though authorized to fix rates for water, cannot arbitrarily fix an unreasonable rate at which a water company must supply water to its citizens. An ordinance fixing rates at which such company shall furnish water is, in an action by the company to recover for water furnished prima facie, a schedule of reasonable rates.—City of Des Moines v. Des Moines Water-Works (Supr. Ct. Ia.) 64 N. W. Rep. 269.

Injunction for Obstruction of Operation of Street Railways.

In the absence of municipal authority regulating the use of streets in which street railways have been constructed under the law and city ordinances, and are in daily use, by persons who claim the right to use such streets in a manner which will necessarily interfere with the running of the cars on such railways, or with the appliances constructed to propel such cars, a court of equity will, when called upon, restrain a party claiming such right from interfering with or obstructing the usual and ordinary running of the cars of such street railway. In the absence of authority for that purpose the president of a street railway company cannot contract with a third party so as to bind the company to suspend the running of its cars and the cutting or the elevation of its wires, so that such party may move a large building upon and along its tracks 111 ft. or more, in order to cross the same.—Millville Traction Co. v. Goodwin. (Ct. of Chancery of N. J.) 32 At. Rep. 263.

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AND
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Radial stay locomotive boilers have been steadily gaining in favor with railway mechanical officers during the past ten years, especially in the districts where bad water is found and frequent washing of the boiler is necessary. Among the manifest advantages over the old crown-bar type are that it is comparatively easy to clean off the crown-sheet and the sediment and scale do not collect as rapidly as with the crown-bar construction. The bearing of these facts on the relative safety of the two types of boiler is obvious. The New York Railroad Commission, however, as a result of its investigation of the explosion of a locomotive boiler on the Delaware, Lackawanna & Western R. R., near Richfield Junction, on Feb. 19, 1896, has seen fit to give a black eye to the radial stay boiler, and says:

> Of the explosions of locomotive boilers which have taken place in this state in several years past, many of them have been explosions of boilers with crown sheets supported by radial stays. While there have been explosions of boilers where the fire boxes have been constructed with crown bars and rivets, the complete destruction of fire boxes in the former type were absent in the latter. Much may be said in respect to the merits of the latter.

We believe it will be news to most master mechanics that the radial stay boiler is in any respect more dangerous than the older form of construction, especially when the radial stays are properly secured. If the Railroad Commission will make extended inquiry, we believe they will find it not at all difficult to find numerous records of explosions of crown-bar boilers in which the destruction of the firebox effected was "complete" enough to satisfy the most exacting.

On another page of this issue we give full illustrations and particulars of the recent bridge accident at Victoria, B. C., by which 55 persons lost their lives. The information which has been furnished us from several different sources leaves no doubt as to the cause of the accident. A wooden floor beam had been left too long in place and had gradually decayed, and it broke under the load of a large electric car heavily loaded with passengers. The rapidly moving car, as the floor sank beneath it, tipped to one side and knocked out one of the main members of the bridge, and the whole structure then fell into the deep water below.

There are some lessons in this accident which those in responsible charge of bridge structures will do well to profit by. It appears that the bridge in question was built for ordinary highway traffic, and was designed to carry a live load of 1,000 lbs. per lineal foot. As the combined width of roadway and sidewalks was 31 ft., this was equivalent to a live load of only 32 lbs. per sq. ft., a figure which speaks for itself to any engineer. Manifestly the proper thing to do if economy was necessary, was to narrow the roadway and sidewalks enough to enable the bridge to carry a crowd without exceeding the load per lineal foot for which it was designed. If a bridge is to be built of a strength suitable for a country highway, then it should be made of a corresponding width; but it is recklessness which cannot be too strongly characterized to make a bridge of a width for a city street and dimension its members as if it were of a width for a highway.

It is not the bridge building companies who are to blame for this dangerous economy in laying down live loads for structures. Every one of the bridge builders, we venture to say, would much prefer to build structures designed to carry the greatest load that can be placed upon them. Those who are to blame are the designers of structures and those who employ them and insist on a trivial economy at the expense of safety. We are aware that it is hard, oftentimes, for an engineer to stand up for what he knows is good and safe practice. To the average alderman, city councillor or other layman, it may look like a piece of theoretical nonsense for the city engineer to insist on designing bridges to carry the weight of a crowd which may very probably never come upon the structure. But the only safe rule for the engineer, notwithstanding such opposition, is to stand out for what he knows to be the safe and the only safe practice. We believe that the engineer who is in such difficulties may make good use of the descriptions of such accidents as that at Victoria, in this journal, to show to those who oppose him the results which may follow a neglect of sound engineering principles with respect to bridge work.

The second point deserving attention, with respect to the Victoria bridge is that although it was only designed for a live load of 1,000 lbs. per lineal foot, several years after its erection an electric car line was allowed to lay its tracks across the bridge, and no investigation, or at least no adequate investigation, was made to see whether the structure was strong enough to take the added load.

We wonder in how many other places this same thing has been done? We wonder how many electric railways are now running over bridges built only for highway traffic, or, perhaps, designed to carry the light horse-car of ten years ago? It must be remembered that the first electric cars were light structures, little more than horse cars with electric motors attached; but every year has seen an increase in the weights of cars and motors; and this is true quite as much on the lines which run through country and suburban places as on the lines in the large cities. The electric car which went down with the Victoria bridge probably weighed, with its load, about 36,000 lbs., and this was concentrated on a 14-ft. wheelbase. Thus, this car alone subjected the part of the bridge which it covered to a load per lineal foot over 2½ times as great as that for which it was designed. With the terrible disaster at Victoria fresh in our minds, it is pertinent to ask whether other bridges which are carrying electric railways are or may be strained thus to a point beyond that for which their members were originally proportioned.

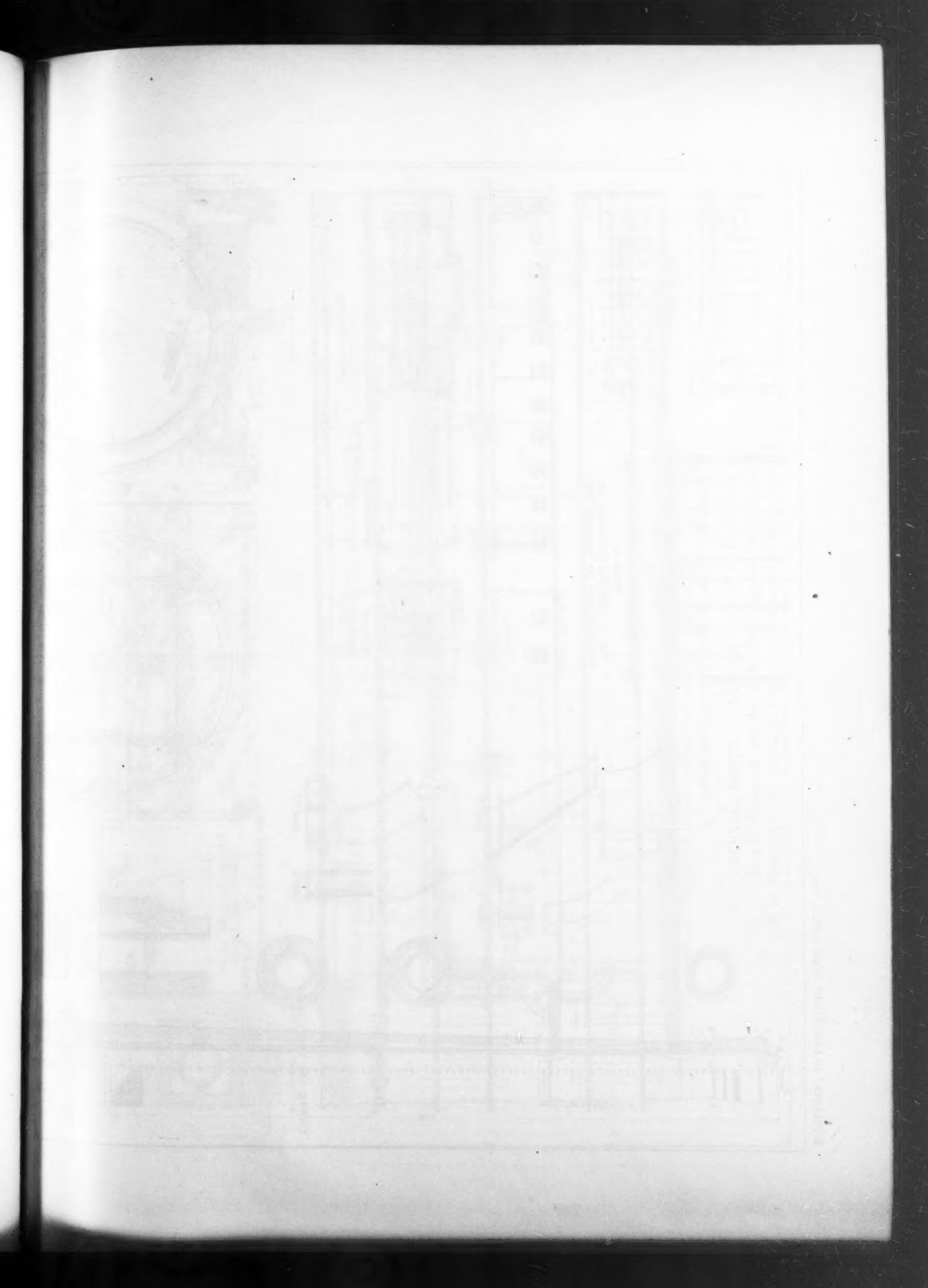
Of the point which, perhaps, had most to do with the failure of the Victoria bridge, the neglect to renew the floor-beams as they decayed, it is not necessary to say much here. Wooden floor beams are seldom used, save in some remote locality where wood is cheap and iron is dear. It may be pointed out, however, that there is probably no part of a bridge structure which is more in need of frequent inspection than the floor-beams. If wooden floor-beams rot, iron beams corrode, and under the leakage from the street surface in a highway bridge or from refrigerator car drippings on a railway bridge, this corrosion may, in some cases, be surprisingly rapid. Few engineers would probably neglect to look after the inspection of wooden floor-beams, and it is fair to say that some of the same watchfulness should also be exercised over iron ones.

There are many other points in connection with the Victoria disaster that may be profitably studied, but we will refer now to only one more, and that is the sequence of events when the bridge fell. According to our information, the car, as soon as it sank under the broken floor-beam, tipped to one side and crashed into the truss, breaking one of the main posts. The truss then collapsed. It may be that the car would not have fallen through the break had the bridge itself stood up. In fact this same car broke a floor-beam three years ago, and escaped going into the river by extraordinary good fortune. But the only lesson that any one appears to have learned from that earlier accident was that that especial car ought not to be used on the bridge; and it was not again so used until the day of the recent fatal disaster.

The important point for the engineer to note, however, it appears to us, is that the truss was knocked down. It is common knowledge that bridge engineers on steam railways now prefer plate girders and riveted lattice girders for all spans up to the extreme economcal limit, and one reason for this is that such structures are much less likely to collapse under the impact of a derailed car than a pin-connected structure. When the spans become so great that pin-connected bridges are necessary, engineers are exceedingly careful to provide a good floor, well protected by guard timbers, so that if a car leaves the track it shall be kept in line and not crash into the bridge trusses and wreck them.

It is difficult to see why these same principles do not hold good and ought not to be applied in the case of electric railways. Their tracks are generally laid along one side of the bridge and as close to the trusses as possible, and any derailment, a broken wheel, a broken axle, or, as in the case at Victoria, the failure of a floor-beam or stringer, is liable to send the car into the bridge trusses, with results which it is not pleasant to contemplate. There are probably hundreds, if not thousands, of electric railway bridge crossings which correspond to the above description; and if the accidents under the circumstances we have pointed out are rare, the fatal record at Victoria shows that they are likely to make up for this when they do occur, by the length of the roll of their victims. If we mistake not, this is the most important lesson for the engineer to learn from the sad fatality at Victoria, and it is to be hoped that it may be widely heeded.

Another point which may be noticed in this connection is the extent to which the overcrowding of cars is permitted on our street railways, and this has been a direct or indirect cause of many accidents, and the cause of much injury in many accidents ndt attributable in any way to overcrowding. The companies make little or no attempt to check this, or even to provide additional men in charge of the crowded cars, and some of them (whose roads carry enormous crowds of people) make the absurd claim that if the number of persons in the car was limited to its proper number or if they provided extra men, the profits would be so reduced that the company would have to go out of business. Such a claim cannot be seriously considered. In the accident at Victoria, noted above, about 140 persons were crowded in and upon a car seating only 60. Filling the standing room on days of exceptional traffic is permissible, according to universal American practice. But crowding passengers in cars without limit is barbarous and ought to be prevented by city authorities. In the runaway accident at Brooklyn, noted last week, the trolley jumped or was thrown from the wire, and as the conductor was in the car trying to collect the fares of the 130 or more persons crowded inside and on the footboards, he could not make any attempt to replace it. If such crowds are to be permitted to be carried (especially in view of the fact that the rope of the trolley pole hangs conveniently to the hand of any mischievous or ill-disposed person on the car platform) there should



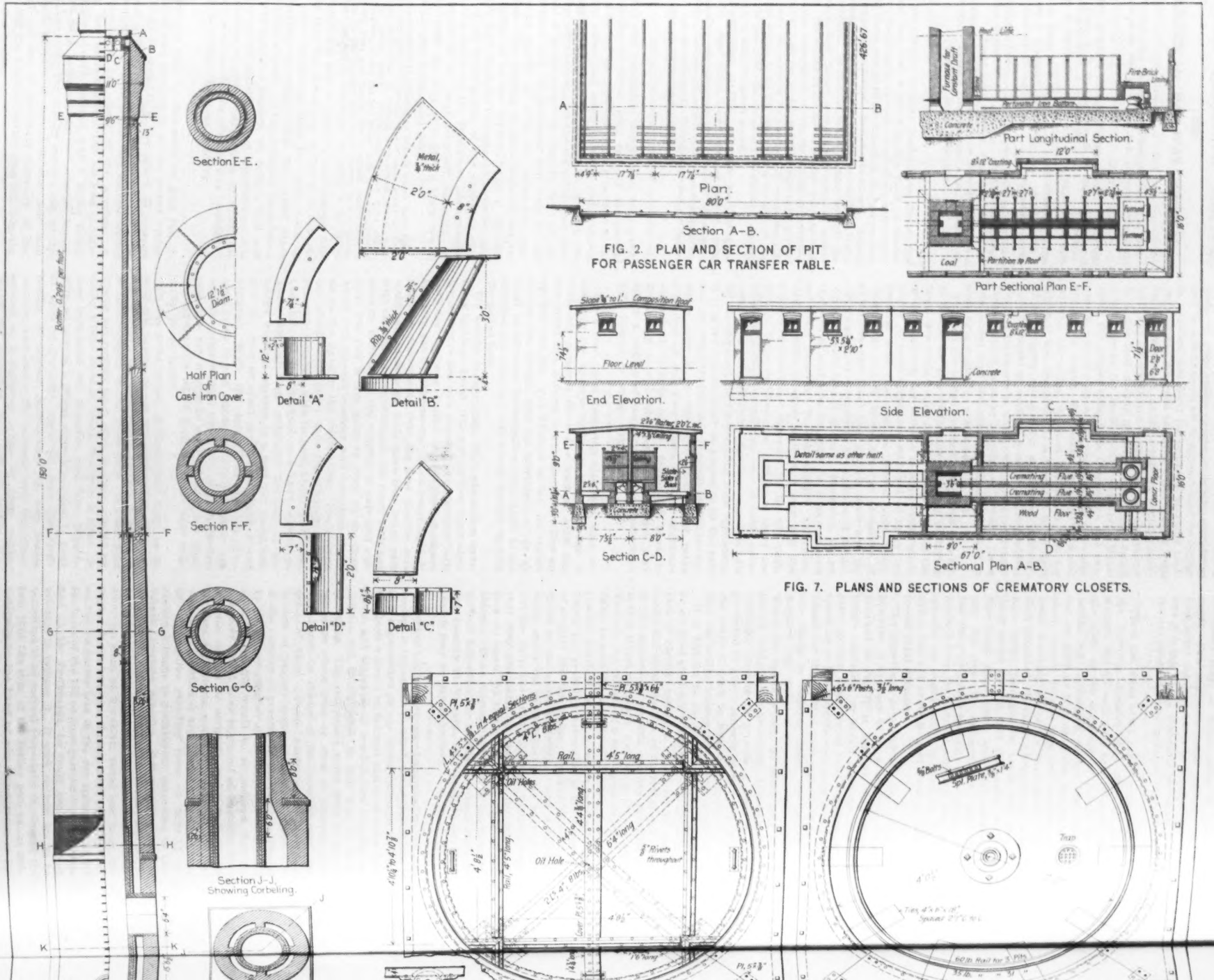
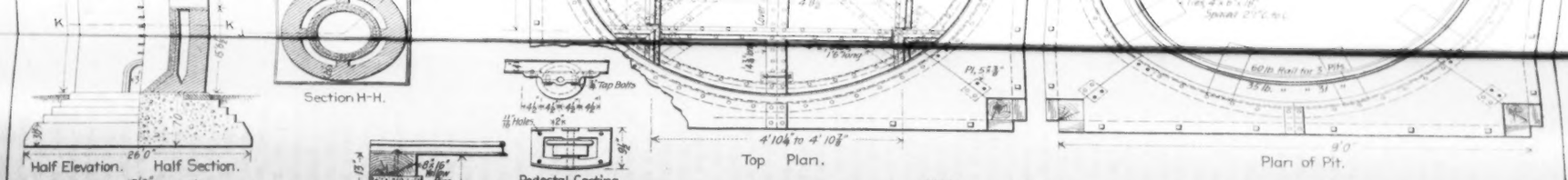


FIG. 2. PLAN AND SECTION OF PIT FOR PASSENGER CAR TRANSFER TABLE.

FIG. 7. PLANS AND SECTIONS OF CREMATORY CLOSETS.



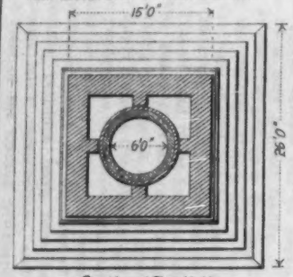


FIG. 11.
CHIMNEY FOR BOILER HOUSE.

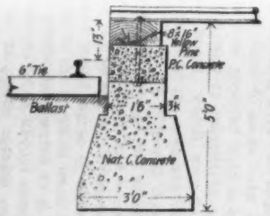


FIG. 3. ENLARGED SECTION OF SIDE WALL FOR PIT OF PASSENGER CAR TRANSFER TABLE.

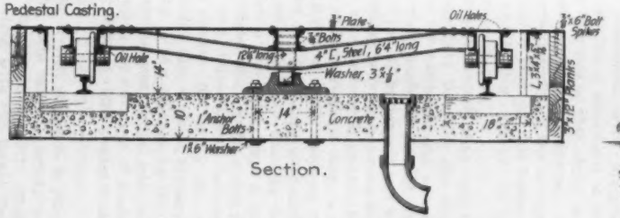
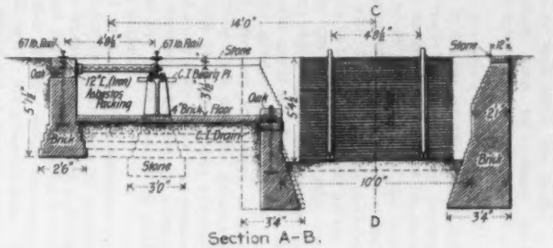


FIG. 5. DETAILS OF PUSH CAR TURN TABLE.



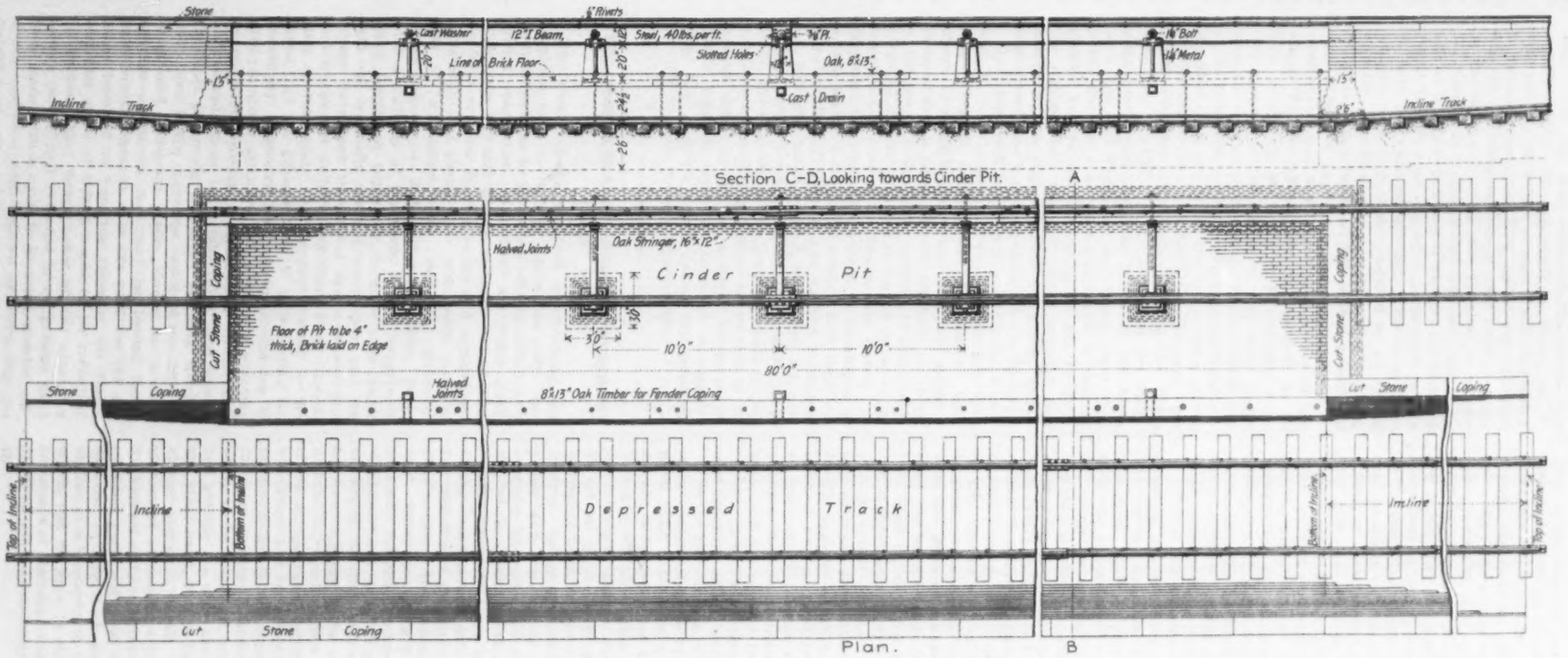


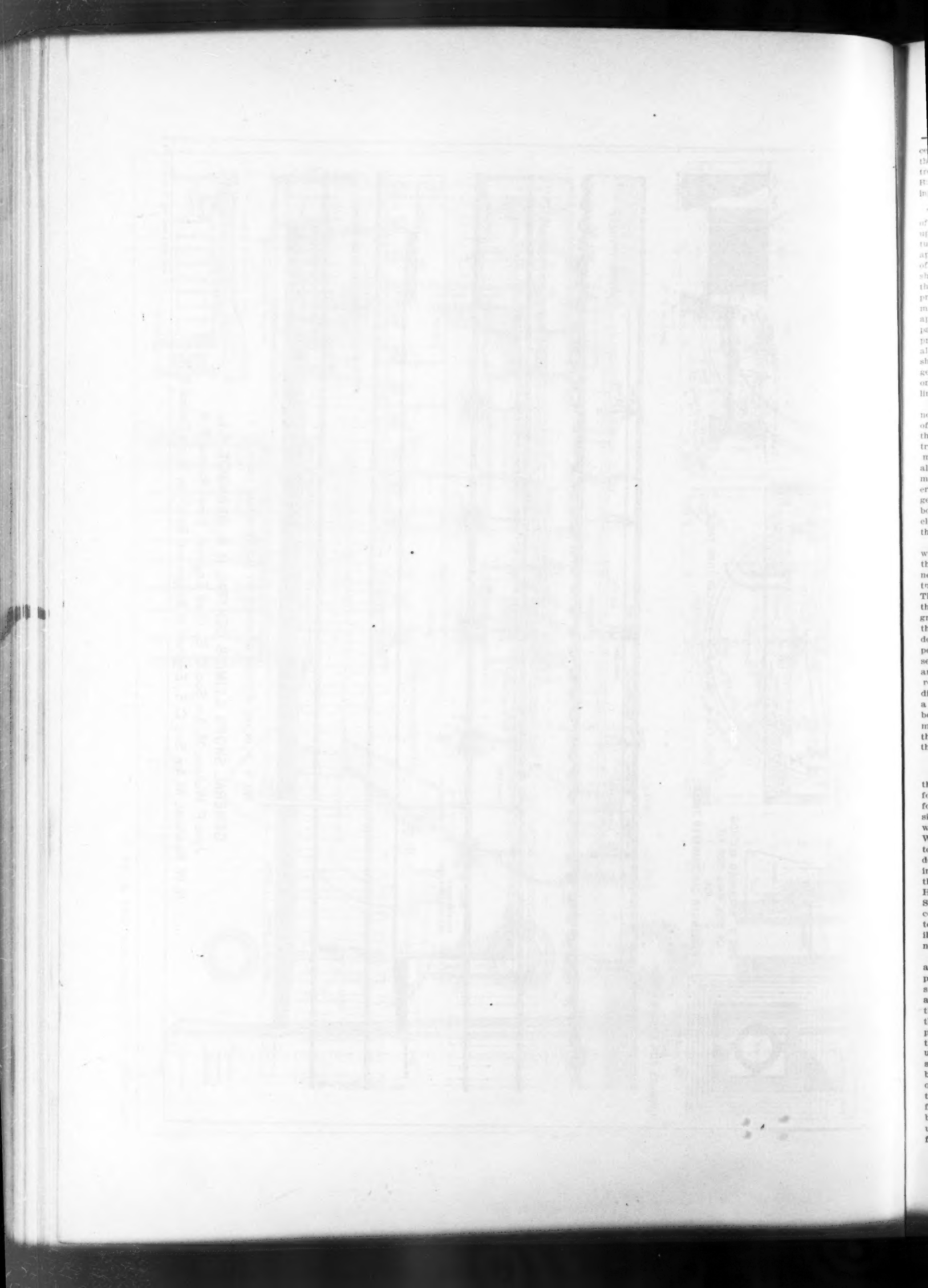
FIG. 4. PLAN AND SECTIONS OF CINDER PIT AND DEPRESSED TRACK.

GENERAL SHOPS ILLINOIS CENTRAL R. R., BURNSIDE, ILL.

John F. Wallace, M. Am. Soc. C. E., Chief Engineer, Illinois Central R. R.

H. W. Parkhurst, M. Am. Soc. C. E., Engineer of Bridges and Buildings, Illinois Central R. R.

CHAS. HART & SONS, LITH., 34 VESEY ST., N. Y.



certainly be one man stationed permanently on the rear platform to look after the brake and trolley, and another man to collect fares. But it would be much better to forbid such crowding.

The commission in charge of the construction of the new East River Bridge is about deciding upon the locations for the terminals of its structure, and of course is meeting with the usual appeals from the property-owners in the vicinity of each terminal who desire that the terminal shall be so located as to benefit their real estate in the greatest degree. On the Brooklyn side, some property-owners are objecting to having the terminal extended to the point required to give the approach a suitable grade, urging that it will pass them by and diminish the value of their property. On the New York side the merchants along Grand St. urge that the bridge approach should be turned at a right angle to land passengers in that street instead of carrying it straight on to a terminus at the intersection of its grade line with the street surface.

It is to be hoped that the Commissioners will not be swerved from their plain duty by appeals of this sort. Their business is to build a bridge that will be the most convenient possible for the travelling public and in the most economical manner consistent with first-class work. To alter the grades or alinement of such a structure merely to help this or that street or block of property would be manifestly unwise. As respects the general arrangement of the terminal, it is to be borne in mind that on this bridge the Brooklyn elevated and trolley cars are to have tracks for their accommodation.

It is likely, therefore, that very few passengers will change cars to cross the bridge, and thus the reason for extending the terminal to a point near a central business district which existed in the case of the old bridge will not be present here. The only thing the Commissioners have to consider, therefore, is to make their approaches with proper gradients and to terminate them in such a manner that all classes of traffic reaching the bridge may do so with the least crowding and danger. Experience seems to show that the best results are secured when the exits from a bridge entrance are so arranged that traffic going in different directions can immediately separate and take diverging streets. To empty the entire traffic of a great bridge into a street already thronged has been shown to be a mistake by the New York terminal of the present bridge, and this is especially the case when the currents of traffic to and from the bridge cross at right angles those in the street.

The rapid transit situation in New York city at the present date may be briefly summed up as follows: The Manhattan Ry. officials at the informal meeting with the Rapid Transit Commission, on June 4, made very liberal propositions which were received with a good deal of favor. When it came to submitting a formal proposition to the Board, which was done on June 11, it developed that the company was much more willing to build its proposed down-town extensions than it was to build the extensions north of the Harlem River which had been discussed. Mayor Strong laid down the ultimatum that unless the company would agree to build the proposed extensions to the north at once, no additional privileges should be granted to it. This brought the negotiations to an abrupt conclusion.

So far as public opinion can be gaged, there appears to be a very general feeling of disappointment at the veto put upon the Rapid Transit plan by the Supreme Court, and a sentiment also that the plan should not be given up but that new legislation should be secured to enable the Rapid Transit road to be built as originally planned. The Board of Trade and Transportation, at a meeting on June 10, adopted resolutions urging the Rapid Transit Commission not to resign but to "undertake to devise such measures, by legislation or otherwise, as will remove the obstacles which obstruct the progress of rapid transit." Similar petitions have been received from prominent labor organizations, and other bodies; and most of the leading newspapers are urging this course, and opposing the grant of further privileges to the Manhattan Co.

We discussed in our issue of June 4, the question whether the proposed Rapid Transit railway would pay, and answered the query of a correspondent who expressed a doubt as to whether it could secure enough traffic to make it a paying enterprise. The same correspondent has since written us saying that after a study of the figures given in our editorial he admits the volume of traffic which will seek the road, and his only question now is whether the proposed Rapid Transit road can carry passengers enough to earn the required amount. This is a doubt which can be very easily satisfied by an appeal to facts. We showed in our issue of June 4, by incontrovertible facts and figures, that a traffic of only 85,000,000 passengers per annum would be sufficient to pay the operating expenses of the Rapid Transit railway and the interest on its cost, estimating the latter at $50,000,000. Now, this number of passengers is very little larger than the regular traffic on the Sixth Avenue line of the Manhattan system. We have figures showing that on a day when the total traffic of the Manhattan system was 658,347 passengers, the Sixth Ave. line carried 253,762 and the Third Ave. line, 224,286. On the same day the maximum traffic per hour was 27,842 on the Sixth Ave. line and 30,638 on the Third Ave. line. While this was a day of heavy travel, it was not greatly beyond the average after all. In 1895, the average daily traffic, Sundays included, was 514,000 on the entire Manhattan system, and it has carried over a million passengers in 24 hours.

Now, the Sixth Ave. line is a double-track railway, 11 miles in length. The proposed New York Rapid Transit railway was designed to have about 13 miles of four-track line, and about 6 miles of double track. It will be plain, we think, to any one, that the traffic capacity of this system would be greatly in excess of that of either of the double-track lines of the Manhattan system. In fact with the advantage gained by separation of a long distance and local traffic; with loop terminals facilitating quick and uniform despatching, with the firmer roadbed, and, above all, with electric motor power, enabling quick starts to be made, the capacity of the proposed rapid transit system would probably largely exceed that of the present entire Manhattan system. Whatever its traffic capacity may be, however, it appears clear that it would largely exceed the minimum required to make it a paying enterprise.

THE CONSTRUCTION AND OPERATION OF RAILWAY YARDS.

The great expense involved in switching and handling cars in railway yards has only been fully recognized by operating officers within very recent years, and while there are many yards which are well laid out for economical operation, yet as a rule the general design and detailed arrangements of yards have been made more or less at hap-hazard, with consequent difficulty, delay and expense in handling the traffic. Probably a majority of the yards of any importance have developed gradually from smaller yards laid out originally without much care, and the tracks have been lengthened and new switches and tracks put in here and there from time to time as immediate requirements seemed to demand. At the present time it is becoming increasingly necessary for railway companies to give particular attention to questions of economy in operating, owing to increasing competition and to reductions in freight rates, and among the most promising points for effecting marked reductions in the operating expenses are the terminal and divisional yards. Under the present average conditions cars may be hauled for a considerable distance over the road for the expense involved in handling them at the yards, and this state of things needs to be remedied. In various other departments of the operating service careful and extended investigations have been made with a view to securing greater efficiency combined with reduced expenses, but the freight yard offers a wide and, to a large extent, an unexplored field for such investigation and improvement.

Defects in yard design are very frequently due to a lack of co-operation between the constructing and operating officers. In some cases a yard is enlarged or extended without the assistance of the engineer, and the result is an awkward arrangement of curves and switches which increases the difficulty of handling cars and increases the wear on rails and wheels. In other cases the engineer has sometimes planned and located a freight yard without inquiring into the local conditions and the traffic requirements, with the result that the yard, while appearing very convenient on paper, is a source of much trouble to the operating department. Thus the switches may be badly located, or the track scales, repair tracks, or other special points may be so located that they can only be reached by crossing or fouling other tracks which are in constant use. Most railway engineers give too little study to the operating side of railway service, and in consequence do not realize the importance of many smaller items and details in economizing work, or realize their relation to the general operating expenses of the railway. For these and other reasons it is imperative, in the interests of efficient service that the officers of the constructing and operating departments should consult together as to the best arrangement for any one yard, while information should be sought from the yardmaster or other local officer as to any special or local service to be provided for, or any special difficulties resulting from the existing arrangement. As already noted, this practice very rarely obtains, and yards are as a rule extended or enlarged piecemeal and without any consideration as to the relation of the new tracks to the general plan of the yard. Such a yard becomes eventually a mere patchwork of additions and extensions added on to a small original yard, the involved and complicated arrangement then resulting in much extra maintenance work and in much unnecessary work and delay in handling the traffic. In large yards the traffic is usually so heavy that entire reconstruction is practically impossible, but a good design should be planned, and no important changes should then be made on the ground until the plans for such changes have been compared with the general plan, and the reasons for the changes carefully considered by the officials familiar with the regular handling of the traffic.

The too general idea of a yard is that the principal consideration is to have plenty of tracks upon which to store cars, but as a matter of fact a yard is intended for sorting and distributing cars and not for storing them. The quicker the car is passed through the yard from the time of its arrival off the road until it is delivered at its unloading track or sent out again to continue its journey, the greater will be the operating efficiency and economy of the yard service. This economy and efficiency will also extend through the whole freight service, for if the cars are handled promptly there will be less delay in providing empty cars as called for, and consequently the capacity of the equipment will be increased, thus avoiding the necessity of purchasing new cars. There are not a few roads on which the necessity for the purchase of additional freight equipment has been due largely to the detentions of cars in the divisional and terminal yards and by the consignees. Better arrangement of the yards and the introduction of a demurrage system to check unreasonable detentions of cars by freight consignees has, on many roads, effected decided improvements in this direction. If a yard is too large, or its track capacity too great, there is likely to be a lack of promptness in clearing it and getting the cars moving over the road. On the other hand, if it is too small, blockades will almost certainly occur, interfering with the movement of freight trains on the road, while the hurried and complicated switching in an overcrowded yard will tend to greatly increase the damage to rolling stock. In all yards there is more or less of a tendency to rough handling of cars, which can be kept in check only by strict enforcement of discipline and a full enquiry as to the cause of and responsibility for each case of damage.

One important defect resulting from the general failure to recognize the relation of yard service to the general operation of a railway system is the common failure to provide proper equipment. Any old rails and track material are con-

sidered good enough for yard tracks, and the average condition of the ordinary locomotives for yard switching is only one remove above that of the locomotives allotted to the despised gravel train, although it must be admitted that there is a growing recognition of the expense involved in using worn-out road engines of light power for work-train service. Not only are the yard tracks very often of bad construction in the first place, but their maintenance is more or less neglected, and low joints, missing bolts, loose spikes, worn ties, and switches and frogs in various grades of bad repair are common conditions to be met with in the average yard. This is partly due to weakness of the tracks as originally built, for the sectionmen in charge of the yard, finding it impossible to keep all these tracks in proper condition under the traffic which they sustain, naturally become more or less careless and discouraged. In a recent editorial we commented upon this fact, in its relation to the passenger yard of the Grand Central terminal station in New York city, where 100-lb. rails (for switches and frogs as well as tracks) are gradually replacing the 65-lb. rails, giving a vastly better and more permanent track, which requires less than half the number of men and amount of work for maintenance. Besides the general maintenance work there is also a decrease in the amount of repairs and extra work due to the derailments which are of frequent occurrence in ordinary yards, and more especially in freight yards. The condition of the switching engines is frequently on a par with that of the track, the tires being worn hollow to an extent which is most destructive to the track, while the valves are badly set, and all the connections are more or less loose. It is not in the nature of the average engineman to give his best endeavors to the proper handling of such a "mill," so that the amount of damage to cars in switching will probably bear some relation to the amount of maintenance expenses for tracks and engines. Another point which may be mentioned in this connection is the failure to provide proper lighting for the yards, night work being done under adverse conditions by the aid mainly of small hand lamps. It must be admitted that the proper lighting of a yard is not an easy matter, owing to the interference of cars, whose black shadows alternating with lighted spaces, and moving from place to place, may be more dangerous than a uniform darkness to which a man's eyes become more or less accustomed. Nevertheless the matter is not impossible of solution, and there are already some few yards which are efficiently lighted.

Where large yards exist in busy city districts it would often be real economy to sell the land and lay out new yards in an outlying district. If, however, the conditions are such that the yard must be kept, then it will be economy to see how far space can be economized, so as to get as great a concentration of work as possible. In this respect English railway practice is superior to American practice, as was pointed out in our issue of July 11, 1895, when we briefly discussed a paper by an English railway manager on "Freight Stations and Yards on English Railways." The great attention paid to this matter, necessitated by the very high value of land, has enabled them to devise methods for handling enormous quantities of freight in city terminals of restricted area, while even the outlying and divisional terminals are laid out with greater care and with a greater attention to the operating side of the question than is common in this country.

The discussion in detail of the existing arrangements of individual yards can be of but little value, since the conditions and requirements, and the nature and extent of the traffic, are so diverse; and what may be a proper and desirable plan at one yard may be entirely inapplicable at another. In another part of this issue, however, we publish a comprehensive article on the principles involved in yard design and yard work, and the point to be specially considered in a typical design. The details of the design of any actual yard should conform as closely as possible to these general principles and general rules. It may be said without hesitation that on nearly every railway it would pay to have an extended and systematic investigation made as to the construction and operation of each important yard, and as to the means by which increased efficiency and economy can be secured; and then to follow such an investigation by a prompt and systematic undertaking of the improvements which are found to be desirable and practicable.

LETTERS TO THE EDITOR.

Growth of Passenger Traffic in New York City.

Sir: In your editorial of June 4th, under the head of "Would a Rapid Transit Railway in New York City Pay?" you quote the traffic returns of the elevated and surface railway companies, for the year ending June 30, 1895, and from those figures deduce certain results.

It is not generally recognized with what rapidity railway traffic is increasing in New York city, and at a rate considerably faster than the growth of the population. The following table gives the total number of passengers carried on the surface and elevated railways for each fiscal year from 1871 to 1895 inclusive:

	Surface roads.	Elevated roads.	Total traffic.
1871.....	129,971,000	.....	129,971,000
1872.....	138,700,000	167,000	138,867,000
1873.....	139,900,000	644,000	140,544,000
1874.....	149,800,000	796,000	150,596,000
1875.....	164,800,000	920,000	165,720,000
1876.....	165,200,000	2,012,000	167,212,000
1877.....	163,700,000	3,011,000	166,711,000
1878.....	159,900,000	9,200,000	169,100,000
1879.....	140,700,000	45,900,000	186,600,000
1880.....	142,000,000	60,800,000	202,800,000
1881.....	150,400,000	75,600,000	226,000,000
1882.....	166,500,000	86,300,000	252,800,000
1883.....	176,600,000	92,100,000	268,700,000
1884.....	187,400,000	96,700,000	284,100,000
1885.....	193,700,000	103,300,000	297,000,000
1886.....	210,500,000	115,200,000	325,700,000
1887.....	202,400,000	159,800,000	362,200,000
1888.....	197,500,000	173,900,000	371,400,000
1889.....	206,300,000	182,800,000	389,100,000
1890.....	218,500,000	189,900,000	408,400,000
1891.....	226,900,000	201,200,000	428,100,000
1892.....	239,500,000	213,700,000	453,200,000
1893.....	243,374,463	221,407,197	464,781,660
1894.....	245,726,197	202,751,532	448,477,729
1895.....	281,849,680	187,614,985	469,464,665

The 25 years here represented show the growth in street railway traffic, with an average increase of 13,579,746 passengers per annum. In 1870 the population of the city of New York was 1,206,299, and in 1892, according to the State Census, it was 1,801,739, an increase of over 49%. In the same period the street railway travel had increased from 129,971,000 to 464,781,660 passengers, an increase of over 265%, that is to say, the rate of increase of railroad travel has been over five times greater than that of population. Or, putting it in another way, in 1870 there were 108 trips for each inhabitant, while in 1892 there were 251.

It is generally assumed (and you yourself assume it) that the construction of a rapid transit railway would draw traffic from other roads. An examination of the above table shows that such has not been the case in the past, but that each new road constructed has, after a very short period, helped to increase the traffic of the previously existing lines. The rapid development of the elevated railways from 1876 to 1879 caused a falling off in the traffic of the surface roads, although the total travel of the city was increasing. After the year 1879 conditions became readjusted and the surface roads again showed increases. In fact, from 1880 to 1886, their traffic was increasing at a much faster rate than it was previous to the construction of the elevated roads. The most striking fact of all, however, occurred in 1887, when the elevated railways voluntarily reduced their rate of fare from ten to five cents and their traffic was increased 44,000,000 passengers in one year, or a sudden increase of about 40%. In spite of this extraordinary growth, the surface railroads lost in that year but 7,900,000 passengers, and by 1890, although the growth of the elevated railways was still proceeding at a very rapid rate, the surface railroads had again passed their previous high water mark. Another circumstance in this connection is the fact that although the elevated railways made this big reduction in fare, nevertheless not only were their gross receipts increased, but their net receipts were actually increased by this reduction. After the year 1893, the elevated railways commenced to show a decrease, owing to the improvement in surface traction and the general stagnation in business. It is quite probable that when conditions have again readjusted themselves, that the experience of 1876-1879 will be repeated, and that both the elevated and surface systems will again show rapid and uniform increases. The year 1894 is the only year on record in a quarter of a century which shows a decrease in the traffic from the preceding year. That this was due to the hard times and not to destructive competition there is no doubt. It will be noted that the year 1895 not only shows a large increase of nearly 21,000,000 passengers over 1894, but also shows an increase over the previous highest year, 1893. The effect of the hard times in 1894 is clearly proved by the traffic returns of the Brooklyn Bridge, the railway of which is subject to practically no competition at all, and yet the passengers carried by it during the year 1894 were 910,870 less than were carried in 1893, the total figures being 41,702,235, as against 42,715,105.

There is no city in the world where the demand for street traffic facilities is so great as in New York, and the one great difficulty of meeting this demand is, that each extension of facilities obtained rather tends to increase than to diminish the trouble.

A study of the above figures I believe will be interesting to your readers and answer in the best possible way your question of whether a rapid transit railway in the city of New York would be profitable. I believe it answers it not only in the affirmative, but also indicates that such a road would create traffic for itself, and not at the expense of competing lines. Very truly yours,

Wm. Barclay Parsons, M. Am. Soc. C. E.

22 William St., New York city, June 11, 1896.

Civil Service Examinations.

Sir: The New York City Civil Service Board will hold an examination for leveler on June 25, 1896, at 10 a. m. Citizens of the United States over 18 years of age are eligible to this examination. The salary ranges from $800 to $1,500. The examination will consist of writing, arithmetic, technical knowledge and experience. Applications may be obtained by addressing the undersigned.

S. William Briscoe,
Secy. New York City Civil Service Board.

New Criminal Court House, New York city,
June 10, 1896.

BURNSIDE SHOPS, ILLINOIS CENTRAL R. R.

(With inset.)

I.

Track and Ground Constructions.

An important part of the extensive improvement work which the Illinois Central R. R. has been doing upon its terminal lines entering the city of Chicago, since 1892, has been the construction of general repair shops at Burnside, about 12 miles south of that city. This plant, which comprises both locomotive and car repair shops, deserves to rank among the largest railway shop plants in the country, and its recent construction makes it a good example of the best modern practice in this line of work in America. A description of its salient features is, therefore, of interest to engineers, and through the courtesy of Mr. John F. Wallace, M. Am. Soc. C. E., Chief Engineer, Illinois Central R R., Engineering News is enabled to present the drawings and description published in this and succeeding issues.

The main line of the Illinois Central R. R., coming from the south, occupies a strip of right of way, about 200 ft. wide, directly on the shore of Lake Michigan, fronting the city of Chicago and extending from 51st St. north to the Chicago River. South of 51st St., the company's right of way diverges west from the lake shore and passes a block or two west of Jackson Park, the site of the World's Columbian Exposition. Previous to 1892 all streets crossing this right of way, viz., 51st St. and those south of it, were at grade with the railway tracks, but in that year the Chicago City Council passed an ordinance requiring the company to elevate its tracks from 51st St., south to 67th St., with viaducts over the crossing thoroughfares. In response to this ordinance and the probable demands of the Exposition traffic to Illinois Central R. R. Co. began an extensive series of improvements, including, of course, the track elevation as ordered, but with the addition of a general remodeling of its whole terminal facilities. To permit of these changes and also because the old shops had become crowded, it was decided to build new shops farther from the city.

The old shops had been quite widely separated; the locomotive and machine shops being located on the lake shore between 12th and 16th Sts., and the car shops nearly ten blocks south, in the vicinity of 26th St. It was, of course, decided to have the shops closer together in the new plant, and also to provide for future enlargements. A tract of land, 160 acres in extent, was secured at Burnside, and on this locomotive and machine shops were built in 1892. In 1895 car shops were added and have been put in operation within the last six months.

With the foregoing introduction attention may be turned to the actual description of the shops. Fig. 1 is a general plan of the railway and push-car track systems, water supply system, sewerage and drainage systems, and all buildings and

other structures comprising the plant. Each of these different constructions is designated by appropriate symbols and titles. This drawing was made direct from the latest revised plans of the railway company, and is the first complete map of the plant to be published. Each of the different features of the plant will be described separately, and in such detail as its importance may warrant.

Track Systems.—There are two systems of tracks, one for regular locomotive service and another for push-car service, and both systems are of standard 4 ft. 8½ ins. gage. A single switch diverges from the main line track at the north end of the tract on which the plant is built, passes inside the yards and connects again with the main tracks at the south end of the tract. From this main switch diverge the several lines entering among the buildings and these again have such switch and spur lines as are necessary. The push-car track system is formed partly by the regular tracks and partly by independent tracks, which connect by means of turntables. This means that push cars run over the regular track system and also over a considerable mileage of special push-car lines, where the use of locomotives is not necessary or advisable. It will be noticed also that transfer tables provide for reaching certain tracks which are not accessible directly by switches. It may also be noted that the regular track system divides the main buildings into three groups, viz.: buildings devoted to locomotive work at the extreme left, buildings devoted to car work at the extreme right, and between these two groups, a third group of buildings common to both locomotive and car work, i. e., oil house, store house, boiler house, etc. This feature will be considered further on. We will note here only that aside from the arrangement of the tracks, which is clearly shown by the drawings, there is little noticeable in their construction. Those outside of the buildings have 60-lb. rails laid on cross ties in cinder ballast and those inside the buildings vary in construction according to their purpose and the nature of the floor systems of the buildings.

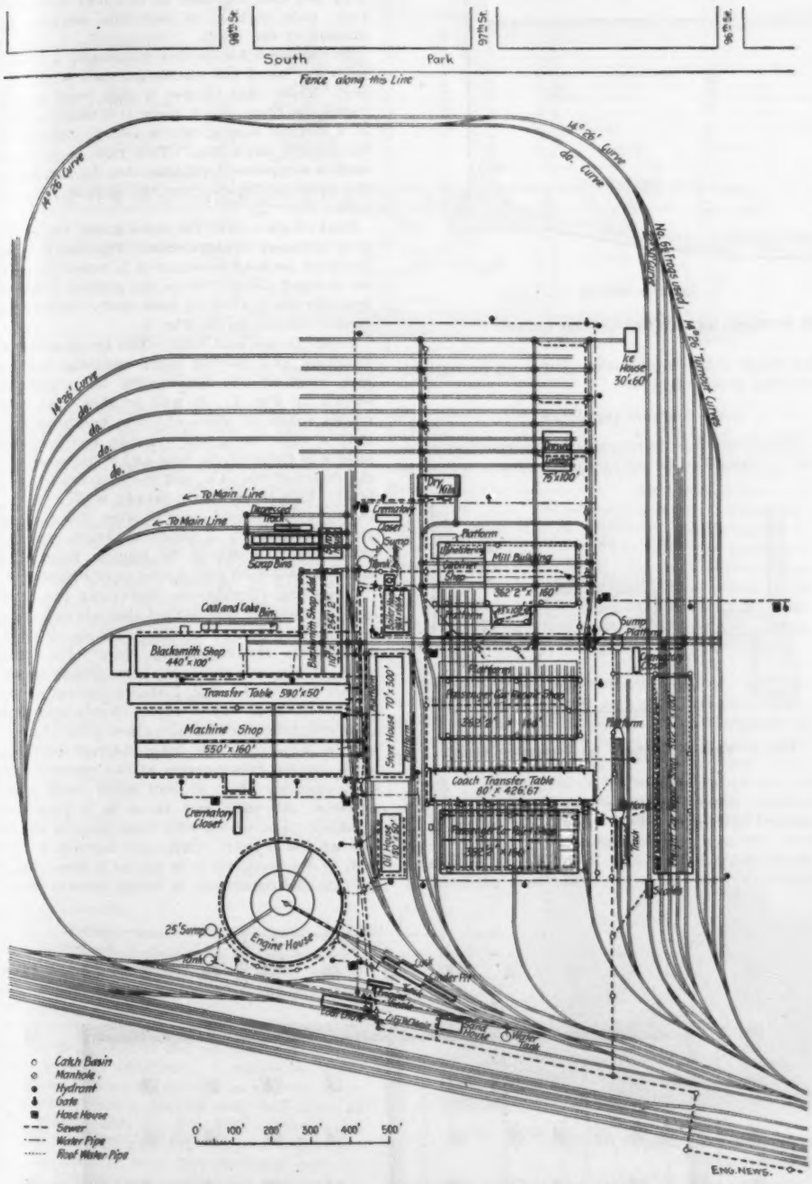


FIG. 1.—GENERAL PLAN OF SHOPS OF ILLINOIS CENTRAL R. R. AT BURNSIDE, ILL.
John P. Wallace, M. Am. Soc. C. E., Chief Engineer.

Sewerage and Drainage.—The roof drainage is conveyed by a system of pipes to a sump from which it is pumped to various parts of the plant for washing, fire protection, and other purposes. The sewage (except excretal matter) from the buildings, and the land drainage are handled by a system of vitrified pipe sewers. A 20-in. main sewer runs part way along the east side of the yards and from this two branch sewers run west into the yards and diverge into the necessary 6-in. and 8-in. laterals. These sewer pipes are shown by appropriate symbols and figures on the plan, Fig. 1. As the excretal matter is handled separately, the sewage is largely surface water, and the waste water from washing in the paint and car shops, the quenching tube in the blacksmith shops, etc., and is discharged without nuisance upon the surface of the ground northeast of the plant. Ultimately as this section becomes built up and the city builds a sewerage system, connection will be made with the shop sewers.

Water Supply and Fire Protection.—There are three sources of water supply; the rainwater from the roof surfaces which drains into sump No. 1; water from two wells which is forced by deep-well pumps into sump No. 2, and water from the city mains. Either one or all of these sources of supply may be pumped from as occasion demands. The water pipes extend all through the grounds and buildings and are provided with the necessary hydrants, cocks, and hose connections, as clearly shown by Fig. 1. For fire protection there are reels of hose at frequent intervals all through the buildings, but more especially in the wood-working shops. Hose houses, containing hose and carts, nozzles, and other fittings, are also located at intervals in the yards. The hose in the buildings are connected directly with the water pipes and are so arranged that unreeling the hose turns on the water. In the yards the hose is connected with the various fire hydrants as may be demanded. There are also in some of the buildings chemical fire extinguishers. The whole makes a very complete fire-protection system, with ample water supply. For fighting fire the employees are organized and frequently trained to handle the various apparatus.

Electric Lighting System.—This system is not shown on the map, but it is deserving of brief mention. To light the shops and grounds there is provision for 200 arc lights and about 1,000 incandescent lights. The dynamos are located in the annex to the machine shop, with the general power machinery for that building, and are cared for by the same engineer, and the lamps are scattered through the building and grounds wherever needed.

The collateral structures for the various systems just described comprise transfer tables, cinder pit, turntables, scales, sumps, hose houses, and miscellaneous small structures. Each of these is described in the following paragraphs.

Transfer Tables.—There are two transfer table pits—one 590 ft. long and 50 ft. wide between the machine and blacksmith shops, and the other 426.67 ft. long and 80 ft. wide, between the passenger car paint shop and passenger car repair shop. The purpose of each is obvious from its location, Fig. 1. As both of these tables are of the same general construction, only the passenger car transfer will be illustrated. Fig. 2 is a part plan and transverse section of the ground construction for this table, and Fig. 3 is an enlarged section of the side wall. The character of the material and all dimensions are given by these drawings. The table proper consists of an iron frame mounted on trucks and carrying the flooring, truck and operator's cabin, and is operated by a Gibbs motor from overhead electric trolley lines.

Cinder Pit.—The cinder pit is a double one and is located northeast of the roundhouse and about 200 ft. away, Fig. 1, and consists of two tracks and two pits proper, with a depressed track between them, on which cars are run to take away the cinders. Fig. 4 shows a plan, elevation and cross-section of the whole structure. The outer rail of the track over the pit is carried on the side wall, and the inner rail on a series of cast-iron pedestals with masonry foundations. These pedestals are braced to the oak coping of the side wall with 1¼-in. wrought iron rods enclosed in and protected by a 4½-in. wrought iron pipe. The floor of the pit is of 4-in. fire brick. The depressed track is built between the inner walls of the two pits and is of such a level in relation to the track over the pit, that the top of a flat car is about on a level with the pit floor. Other details and dimensions are shown by the drawings, Fig. 4. It will also be noticed from Fig. 1 that a line of water pipe is laid on each side of the pit and provided

with cocks from which water may be had for cooling the cinders and washing the pit.

Push-Car Turntables.—To provide for the transfer of the push cars used for conveying material in and about the shops, from one set of tracks to another, there are 34 push-car turntables. All of these turntables are of the same design, except that three, which connect with the main tracks, have 60-lb. rails, instead of 35-lb. rails. The construction of these turntables is shown clearly by Fig. 5, which gives all dimensions. These tables are all operated by hand, and, as stated above, are so located that push cars may be run over the entire system of tracks.

Before leaving the collateral track construction, mention should be made of the engine and car scales, and the table for loading and unloading wheels and axles. This last-mentioned device is located just south of the freight car repair shop, Fig. 1, and consist of a group of four parallel double tracks terminating at each end in a timber platform. At the east end there is a track depressed to such a level that the top of a flat car is level with the platform. Pairs of wheels brought in on cars are rolled off onto the east platform and then onto one of the group of tracks, where they may be stored temporarily or rolled to the west platform and thence conveyed to other parts of the plant in a manner clearly indicated by Fig. 1. The most frequent transfer of wheels and axles is, of course, from the machine shop to the car shops, and in the opposite direction, for the purpose of machining, repairing, etc.

Sumps and Tanks.—Sumps and tanks are provided for the storage of rain water from the roofs and also for the water from the wells. The primary reservoirs are, of course, the sumps, of which there are two. One of these sumps, No. 2, stores the water from the deep wells, and the other sump, No. 1 receives the rain water from the roofs. These sumps are of the same dimensions and construction. A section of one is shown by Fig. 6, which gives all dimensions and the character of the construction. The capacity of these sumps is 200,000 gallons each. The water tanks are of wood and are mounted on timber towers. The largest is located near the powerhouse, has a capacity of 100,000 gallons, and is on a tower 55 ft. high. The others hold 45,000 gallons each, and are the regular standard tank for engine supply. They are filled by pumping from the sumps or from the city water mains, as will be seen by tracing out the lines of water pipes.

Hose Houses.—The hose houses, like the hydrants are practically collateral constructions of the water supply and fire protection systems and are therefore considered here. They are 10 ft. 2½ ins. × 8 ft. 6½ ins. ground plan, 9 ft. high to eaves and 10 ft. high to ridge. The framework consists of 4 × 6-in. sills and 2 × 4-in. studding, with 6 × ⅞-in. ship-lapped sides, and 4 × ⅞-in. inside ceiling. The roof is of 1 × 6-in. stuff covered with "composition." The doors are at the ends. The floor is of cinders. These houses contain the hose carts, with hose and attachments complete.

In describing the track, water supply and sewerage system and their collateral constructions, repetition of dimensions and details given by the illustrations has been avoided as much as possible, and consequently the drawings need to be studied for much of the information which we present regarding those matters.

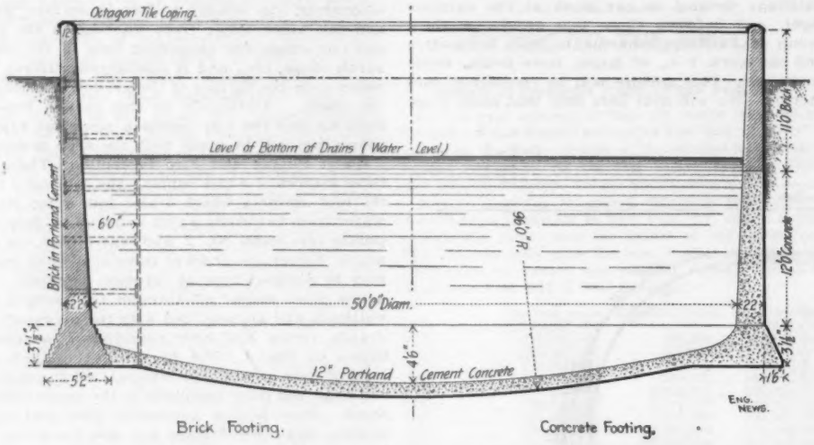


FIG. 6.—TRANSVERSE SECTION OF SUMP FOR STORING RAIN WATER FROM ROOFS.

Minor Buildings.

Minor buildings is necessarily a somewhat arbitrary classification, as often structures minor in size are by no means so in importance. Here, however, minor buildings means practically the smaller buildings. The description of each of these will now be taken up.

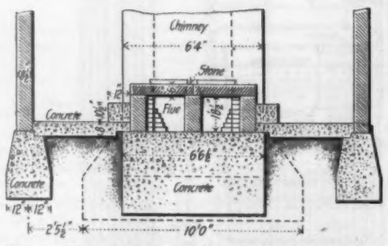


Fig. 8.—Base of Chimney for Crematory Closets.

Sand House.—The sand house is not especially noteworthy, except for the fact that compressed air is used to force the sand from the dry sand bins into elevated bins from which the supply is run into the locomotives. The sand is dried by one of the ordinary sand-drying stoves, to which it is shoveled from the wet sand bin and from which it is shoveled into the dry sand bins. The drying apparatus and dry sand are at one end of the house, and the wet sand bin occupies the opposite end of the building, and a transverse brick partition wall separates them. The dry sand bins, of which there are two, are located one on each side of the stove.

The building is of brick, with a ground plan 62 ft. 8 ins. × 30 ft., and has a door and window at each end and five windows on each side. The roof is carried by ten timber trusses, and is covered by H. W. Johns' asbestos roofing. There are four 6 × 4-ft. skylights. The floor consists of 4 ins. of concrete laid on 8 ins. of sand. As the pressure of the sand against the side walls is considerable they are tied together at frequent intervals with 1-in. rods ending in cast-iron anchors on the outside of the walls.

To charge a locomotive with sand, a chute from each dry sand bin discharges into a sort of hopper. From this hopper a pipe runs to the elevated bin from which there is a chute in the form of a flexible nozzle, which can be inserted in the locomotive sand box. This pipe is so connected with a compressed air pipe that by turning a cock the sand is drawn from the hopper into the elevated bin.

Coal Chute.—Like the sand house, the coal chute is of ordinary construction. The coal is stored in elevated pockets to which it is taken by means of an inclined plane. From the pockets it discharges into the tenders which pass under the building, as shown by the track, Fig. 1.

Scrap House and Bins.—The house and bins for handling and storing scrap material are located just west of the blacksmith shop addition, as shown by Fig. 1. It will be seen that push-car tracks reach all sides of these buildings and also that a spur from the regular locomotive track passes in front of the bins and is depressed so that the floors of the cars and the bins are at the same level. The scrap house proper is 75 × 60 ft., and the bins are in two rows of nine bins each, which are separated by a push-car track, and extend about 190 ft. south of the house. Here all scrap material is sorted and stored until disposed of.

Cremating Closets.—In describing the sewerage system above it was stated that all excretal matter was disposed of by other means. Figs. 7 and 8 illustrate the crematory closets for this purpose. There are three of these closets located as shown by Fig. 1. Fig. 7 shows several elevations and sections of one of these closets and explains their construction and operation quite clearly. As will be seen they are long, narrow buildings of brick divided transversely at the centre by means of a chimney (Fig. 8) and brick walls into two sections. At each end there is a combustition chamber from which two flues pass to the chimney at the center. Only one section, i. e., one-half, of the building is in use at a time; the other half in the meantime is being burned out. The drawings show the arrangements of the flues and other parts and indicate the methods of operation. About 1,500 men use these closets. It is stated that they operate without offensive odor or nuisance of any kind, and so far as a hasty visit could determine the statement appears to be borne out by the facts. Certainly no form of earth

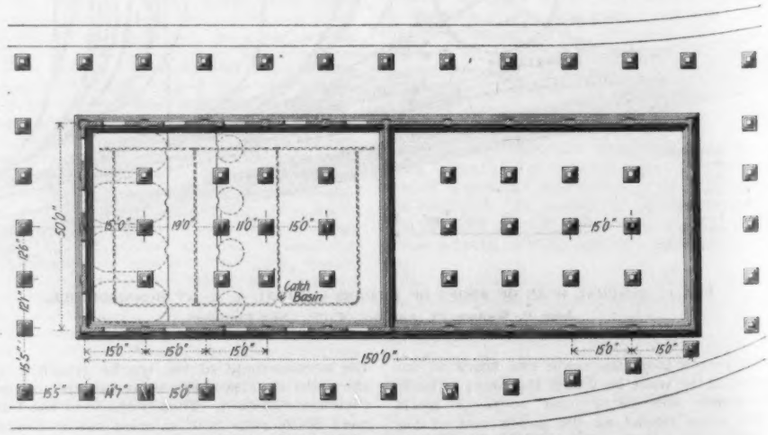


FIG. 9.—FOUNDATION PLAN OF OIL HOUSE.

closets could be so satisfactory under the conditions of use and attention common in large plants of this kind. These closets were constructed by the Fuller & Warren Co., of Chicago, Ill.

Buildings Common to Both Locomotive and Car Shops.

The main buildings of the Burnside plant are divided into three general groups, according to their use and are located in correspondence with this grouping. At the south side of the yards are grouped the engine house, machine shop and blacksmith shop, all buildings for locomotive work and other metal work. At the north side of the yard are grouped the mill building, passenger car repair shop, freight car repair shop, passenger car paint shop and dry kiln, all buildings for car work and other woodwork. Between these two groups are the buildings common to both locomotive work and car work, viz.: the oil house, store house and boiler house. The purpose and advantages of this arrangement are obvious from a study of the general plan, Fig. 1.

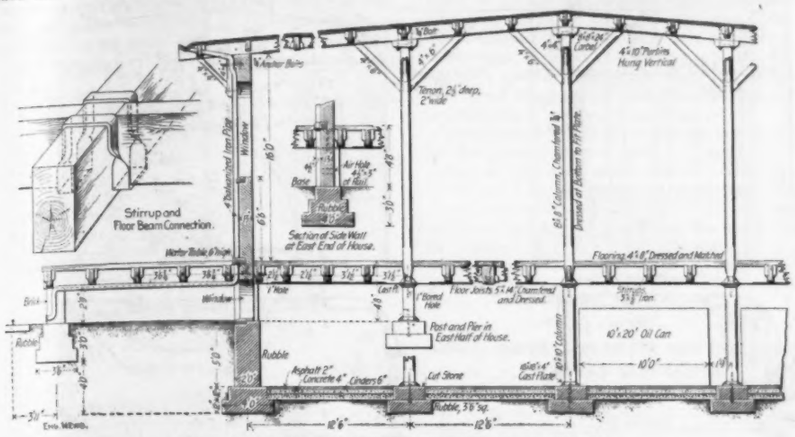


FIG. 10.—PART TRANSVERSE SECTION OF OIL HOUSE.

In the following table are given the main dimensions of each of these buildings:

Character of Building.	Dimensions Ground Plan.
Engine house	316 ft. diameter.
Machine shop	550 × 160 ft.
Blacksmith shop	440 × 160 ft.
Blacksmith shop addition	254 1-6 × 110 ft.
Mill building	362 1-6 × 160 ft.
Passenger car repair shop	362 1-6 × 160 ft.
Freight car repair shop	502 1-6 × 160 ft.
Passenger car paint shop	362 1-6 × 160 ft.
[1]Dry kiln	64 × 54 ft. 7 ins.
[2]Oil house	150 ft. × 50 ft.
[2]Store house	300 ft. × 70 ft.
Boiler house	98.4 × 66.4 ft.

[1]Exclusive of platforms.

The main buildings thus cover about ten acres of ground, exclusive of platforms, sheds, and side structures. In the following paragraphs each is described in order, beginning with the smallest group of general buildings.

Oil House.—The oil house is 50 × 150 ft., c. to c. of walls and is located at the extreme east end of the middle group of buildings. A platform on the level of the car floors surrounds it on all four sides, but the railway tracks parallel only two sides as shown by Figs. 1 and 9. Fig. 9 is a foundation plan of the building and Fig. 10 is a transverse section. As will be seen the building has one story, with a basement under one-half of the building in which are placed the oil tanks. The walls are of brick masonry carried on rubble masonry foundations, and the roof is carried by timber rafters supported on posts. Other features of construction are clearly shown by the drawings.

The main floor of the house is used for storing oil in barrels and as a delivery room. In the basement under the west half are placed the storage tanks, eight in number, four of 8,500 gallons capacity and four of 1,500 gallons capacity. The oil for storage is brought alongside the building on tank cars and delivered to the proper tank by a stationary pipe system extending just under the ceiling of the basement. Proper pipes extend from each tank to the floor above where they terminate in faucets. To force the oil to the floor above compressed air is admitted into the tops of the steel tanks. Only two men are necessary to receive and deliver all oil.

Store House.—In its general structural features the store house differs but little from the oil house. It is 300 ft. long by 70 ft. wide c. to c. of walls, with an 18 ft. 2½-in. platform on all four sides. The railway tracks parallel the two long platforms at such a level that cars can be unloaded directly onto them. There are two stories, and a basement which extends under the whole area of the building and platforms. This basement is used for storing heavy supplies and is reached by two elevators from the platforms. Another elevator gives access to the top floor. On the first floor are stored bar iron and similar supplies, while the top floor is devoted to brass and copper supplies, lamps, brackets, car fittings and the generally more valuable materials. The space between the store house and oil house is used for piling links and pins, angle bars, etc., which are not greatly injured by outdoor exposure. The general offices are also located in the north end of the store house.

The walls of the building are of brick, but the flooring, roof framework and other interior framing are of wood. In the basement the floor consists of 6 ins. of cinders and 6 ins. of concrete. Along the ridge there is a triangular skylight frame provided with the necessary skylights.

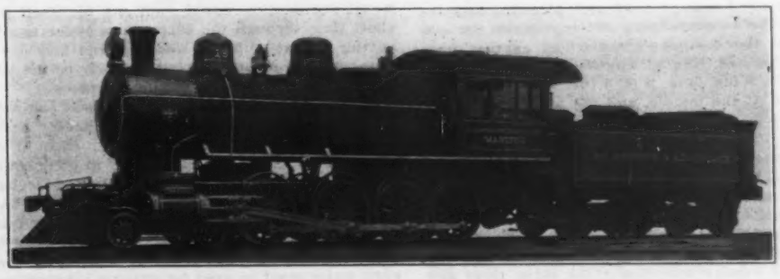
Boiler House.—Power is supplied to the Burnside plant from a central boiler house 98.4×66.4 ft., containing ten tubular boilers of about 150-HP. capacity each. There are no features of particular note about this building, except, perhaps, the steel roof trusses, which are exact duplicates of those used in the boiler shop and which will be described further on, and the 150-ft. brick chimney shown in detail by Fig. 11. Steam from this building is piped to the two engine rooms in the machine shop and the mill building and to other points where it is used for various purposes. There are in this building besides the boilers a Laidlaw-Dunn-Gordon duplex fire pump and a deep well pump. The power machinery proper will be described in another article.

In a succeeding issue of Engineering News, the remaining buildings and appliances of the Burnside shops will be described and illustrated. For the information from which this description has been prepared we are indebted chiefly to Mr. John F. Wallace, M. Am. Soc. C. E., and Mr. H. W. Parkhurst, M. Am. Soc. C. E., Engineer of Bridges and Buildings, Illinois Central R. R. Much aid has also been furnished by Mr. G. F. Jenkins, Superintendent of Construction; Mr. F. W. Brazier, General Foreman Car Department, and Mr. F. E. Place, General Foreman Machine Department.

TWELVE-WHEEL LOCOMOTIVE; ST. LAWRENCE & ADIRONDACK RY.

The enormous size of American freight locomotives for heavy work is becoming a rather remarkable feature of railway motive power equipment, and we illustrate this week a great 87-ton engine of the twelve-wheel type recently built for the St. Lawrence & Adirondack Ry., by the Brooks Locomotive Works, of Dunkirk, N. Y., to whom we are indebted for photographs and dimensions.

Everything about the engine is massive and substantial, and the design is compact and mechanically pleasing. The boiler has a Belpaire firebox with the Player patent improved conical wagon top or throat sheet connection to the cylindrical barrel, the dome being mounted on the throat sheet; while the whistle fitting is mounted independently on the firebox. The sandbox is at the front end of the barrel, and is fitted with the Leach sanding apparatus. The smokestack is placed at the front end of the extension smokestack, instead of at the back, as in ordinary practice. The firebox is designed for burning bituminous coal, and is of great size and length, extending over the axles and frames; it is fitted with a firebrick and the whole boiler is set so high that the handrail on the front end is carried around the lower edge, the upper edge being far above the reach of a man standing on the bumper beam to do cleaning or other work. The cylinders are of exceptional size, but the boiler has ample capacity to supply them with steam. Two-bar or "alligator" guides are used, and the connecting rods are of I section, while the coupling rods are of rectangular section and fish-bellied in shape. Blind tires are used on the two middle pairs of driving wheels, and the engine truck is of the swing motion type, with inside frames and spoke wheels. The tender trucks have diamond frames. Among other special features may be noted the automatic coupler head projecting through the pilot, the round headlight, the great size of the cab, and the well designed steps of the tender. The equipment includes Nathan cylinder lubricators, Monitor injectors, the United States metallic packing for valve stems and piston rods, Dunbar piston packing, Buffalo bronze bearing metal, the National Car Wheel Co.'s wheels for engine and tender trucks, Midvale steel tires and the Ross-Meehan flange bearing brakeshoes.



TWELVE WHEEL LOCOMOTIVE; ST. LAWRENCE & ADIRONDACK RY.
Brooks Locomotive Works, Builders.

A list of the leading dimensions of several of the heaviest locomotives built in this country was given in our issue of May 9, 1895, and we give below, in our standard form, the details of the dimensions of the engine of the St. Lawrence & Adirondack Ry:

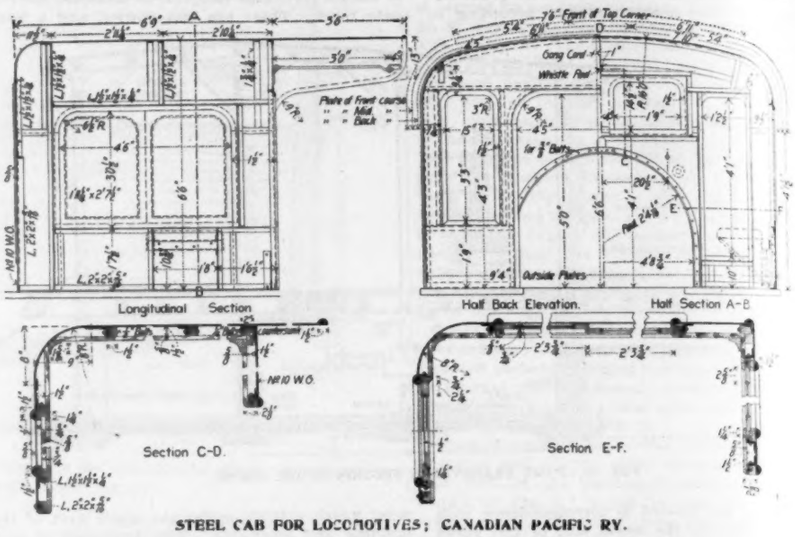
Twelve-Wheel Locomotive; St. Lawrence & Adirondack Ry.	
Running Gear:	
Driving wheels, diam.	4 ft. 7 ins.
Truck wheels, diam.	2 ft. 4 ins.
Tender wheels, diam.	2 ft. 9 ins.
Engine truck	Swing center
Journals, driving axles	8½ × 10 ins.
Journals, truck axles	5½ × 10½ ins.
Journals, tender axles	4¼ × 8 ins.

Wheelbase:	
Driving	15 ft. 6 ins.
Truck	5 ft. 10 ins.
Total engine	25 ft. 5 ins.
Total tender	16 ft. 6 ins.
Total engine and tender	52 ft. 6 ins.
Truck pin to center of leading driver	7 ft. 0 ins.
Wheels having blind tires	Second and third pairs
Weight in Working Order:	
On driving wheels	148,000 lbs.
On truck wheels	27,000 lbs.
Engine, total	175,000 lbs.
Tender, total	90,000 lbs.
Engine and tender, loaded	265,000 lbs.
Tender, empty	37,350 lbs.
Of full coal capacity	15,150 lbs.
Of full water capacity of tank	37,500 lbs.
Allowed for water in boiler	18,000 lbs.
Cylinders	21 × 26 ins.
Distance center to center	7 ft. 3 ins.
Distance center to valve face	1 ft. 5½ ins.
Piston rod, diam.	4 ins.
Form of crosshead and guides	"Alligator" type
Connecting rod, length between centers	8 ft. 7 ins.
Valve Gear:	
Type	Stephenson link
Ports, steam	1⅞ × 18½ ins.
Ports, exhaust	3 × 18½ ins.
Slide valves, lap, outside	⅞ in.
Slide valves, lap, inside	¼ in.
Slide valves, lead	1-32 in.
Slide valves, max. travel	6½ ins.
Boiler.—Type	Player-Belpaire
Diam. of barrel inside	5 ft. 6¾ ins.
Thickness of barrel plates	⅜ and 11-16 ins.
Thickness of smokebox tube plate	¾ in.
Height from rail to center line	8 ft. 9½ ins.
Length of smokebox, outside	4 ft. 8 ins.
Working steam pressure	180 lbs.
Firebox	Belpaire; over axles and frame
Length inside	9 ft. 5 ins.
Width inside	3 ft. 1⅞ ins.
Depth at front	6 ft. 5 ins.
Depth at back	6 ft 2 ins.
Thickness of side plates	5-16 in.
Thickness of back plate	⅜ in.
Thickness of crown sheet	⅜ in.
Thickness of tube sheet	⅝ in.
Grate area	30 sq. ft.
Staybolts, diam. 1 in.; pitch	not over 15 sq. ins.
Water space, width front and back, top, 5 ins; bottom	4 ins.
Water space, width sides, top 6½ ins.; bottom	3½ ins.
Tubes.—Material, iron; pitch	+ 2⅛ ins.
Number	324
Diam. inside 1.875 ins.; outside	2 ins.
Length between tube plates	12 ft. 6 ins.
Total fire area of tube openings	6.21 sq. ft.
Miscellaneous:	
Exhaust nozzle, diam.	5½ ins.
Smokestack, smallest diam.	1 ft. 2 ins.
Smokestack, height from rail to top	14 ft. 5 ins.
Capacity of tank	4,500 gallons
Capacity of coal space	18,000 lbs.
Brake fittings	New York Brake Co.
Tractive force per lb. effective press. on piston	208.5 lbs.
Total tractive force with effect. press. = 4-5 of boiler pressure	32,526 lbs.
Total adhesive tractive power, at ¼ of weight on drivers	37,000 lbs.

STEEL CAB FOR LOCOMOTIVES; CANADIAN PACIFIC RY.

The use of steel for locomotive cabs in this country, although adopted in several instances for road engines, is mainly confined to the engines of elevated railways, on which such cabs are now used almost exclusively. The Canadian Pacific Ry., however, uses on many of its passenger engines a steel cab of neat and pleasing appearance. The accompanying cut represents the cab used on the company's ten-wheel express passenger engines (Engineering News, Aug. 30, 1890). It is 6 ft. 9 ins. long, 9 ft. 4 ins. wide and 6 ft. 6 ins. high at the middle, and the total length over roof extension is 10 ft. 3 ins. The framing is mainly of angle irons ¼ × 1½ × 1½ ins., with corner angles 5-16 × 2 × 2 ins. The sheathing is of No. 10 I. W. G. plate, inside which is a sheathing of ⅝-in. planks, secured to wooden strips 1½ × 1½ ins. bolted to the frame angle irons, so that there is a space 1½ ins. wide between the steel and wood sheathing. The back edge of the roof and the door and window openings in the sides, front and back are stiffened by half-round iron ⅝ × 1½ ins. riveted on the outside of the steel plating. All rivets are 5-16 in. diameter and about 1½ ins. pitch, countersunk on the outside and filed off smooth. The bolts for the wooden scantling pieces are ¼ and ½-in. diameter, and from 4 to 5 ins. pitch. The roof is arched to a radius of 16 ft., joining the sides by curves of 15 ins. radius, and the front and top corners of the cab are curved to a radius of 8 ins. In the front of the cab are two window openings, 14½ × 21 ins., over the boiler head, with glasses 11 × 17½ ins., and there are also two doorways, 49 × 14½ ins., opening onto the running boards. The upper part of each door has a double glass window 24¾ × 11¾ ins. Each side of the cab has an opening 4 ft. 6 ins. × 3 ft. 0½ in., fitted with two sliding sashes having glass 23¼ × 31½ ins. The rear is partly covered in, leaving a middle opening 4 ft. 5 ins. wide and 5 ft. high, with a wing 2 ft. 5½ ins. wide on each side, each wing having a window fitted with glass 11 × 35½ ins. A folding seat is placed on the engineman's side. The boiler head extends about 4 ft. 6 ins. into the cab.

Mr. R. Atkinson, Mechanical Superintendent, informs us that the steel cab costs about three times as much as the ordinary wooden cab, but that the maintenance of the former is almost



STEEL CAB FOR LOCOMOTIVES; CANADIAN PACIFIC RY.

nothing, only a little paint or piece of sheathing inside being required occasionally. The repair of one of these cabs which had the side driven in during a collision only entailed taking out the plates, straightening them, reriveting and painting. There is no particular preference for or objection to the steel cabs on the part of the enginemen, but these cabs are decidedly superior to the wooden cabs when the latter have once begun to get shaky.

PURIFYING WATER FOR LOCOMOTIVE BOILERS.

We have frequently referred to the advantages of purifying the water to be used in locomotive boilers from scale-forming impurities before delivering it to the tenders. This practice has been adopted in England, and there is much reason to believe that many railways in the West and South, where the life of fireboxes and tubes is exceedingly short, would find that a system of water purification would soon pay for itself in a short time through the decrease in boiler repairs, saving in cost of boiler washing, and increase in economy and steam-making capacity of the boilers due to the cleaner heating surfaces.

In stationary boiler practice the best engineers now purify their feed water in a heater before admitting it to the boiler, the other class of engineers pump some sort of "purge" in their boilers at intervals to loosen the scale. Master mechanics where they have done anything at all have followed this latter practice; the use of purifying feed-water heaters being, of course, inadmissible upon a locomotive. But better practice still, where hard water must be used for either a locomotive or a stationary boiler, is to purify the water before it enters the boiler or is heated at all. By the addition of proper chemicals it is possible to precipitate the bulk of the scale-making impurities held in solution in water. These impurities then settle to the bottom or may be removed from the water by filtration.

Recently the We-Fu-Go Company, of Cincinnati has taken up the business of the purification of water for steam boiler purposes by chemical treatment, and has developed a process and apparatus for this purpose, which it claims to be an improvement over any other now in use. The accompanying illustration shows a plan and elevation of the purifying tank designed by this company for use at railway water stations. This tank is placed beside the ordinary locomotive supply tank and is of equal capacity with it, but its bottom is just above the top of the other tank, so that all the water after purification in the precipitating tank will run by gravity into the locomotive supply tank.

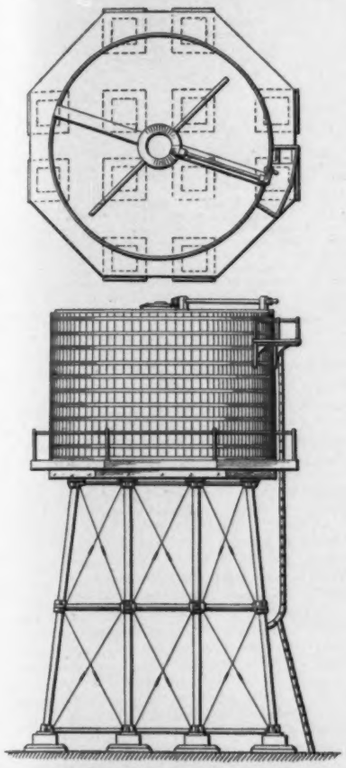
The precipitating tank contains a mechanical stirring device by which the attendant agitates the water for a short time after each addition of the chemical. During this agitation of the water the sludge which has settled to the bottom of the tank during previous purification is mixed up with the water; this insoluble matter very materially aids the purification and precipitation by gathering up the fine precipitate floating in the water.

The method of operating is as follows: The purifying tank is filled with water, and, while filling, the correct amount of chemical is placed in a suitable receptacle, through which the water to the tank passes, and which washes the chemicals into the tank above. As soon as the tank is full the water is shut off, and stirred for 15 or 20 minutes and then allowed to settle. When the storage tank is empty, it is filled with purified water from the precipitating tank, emptying the latter, which is then filled up again. By this plan a tank full of purified water is always ready for the use of the locomotives, and a tank full of raw water is purifying ready to be run into the storage tank when it is empty.

The cost of purifying depends upon the amount and character of the impurities in the water; it costs more to remove the sulphates from the water than it does the carbonates, and of course it would cost more to remove 50 grains of either than to remove only 10 grains, and for similar reasons it requires more labor to keep the boiler which is evaporating water containing 50 grains of lime or magnesia to the gallon clean, than it does a water containing only 10 grains; and it takes more coal to produce the same amount of steam if there is a heavy scale on the plates and tubes instead of a light scale.

Mr. N. O. Goldsmith, the Vice-President of the company, informs us that the following actual results have been obtained in stationary plants where this company's method of treating water has been put to a practical test: In Hamilton, O., where the water contains about 19 grains of impurities to the U. S. gallon, the company named above has one of its 200 HP. water purifiers in operation. More than fifty analyses of the purified water have been made, after it left the tanks, and the total residue varied from 4.58 grains to 7.08 grains per U. S. gallon, the lime varied from a "trace" to 0.83 grains, the rest of the impurities consist of organic matter from 1 to 2 grains, with fractions of a grain of silica, iron, alumina and soda. This water has been fed into the boilers for six months, it has formed no new scale, and considerable old scale has been removed. The heater has not been cleaned since it was put up, where formerly it required cleaning every two weeks. The cost of purifying the water is a trifle under 3 cts. per 1,000 gallons, all the work being done by the engineer. No additional man is required to look after it.

This same company has a similar purifier in Dayton, O., treating water having 25 grains of impurities to the U. S. gallon. From a number of analyses made of the purified water it has been found that the lime remaining amounts to about 1¼ grains per gallon, and total residue of about 9 grains per gallon, composed of organic matter, silica, iron, alumina and soda. The cost of purifying is about 4 cts. per 1,000 gallons. The apparatus is operated by the engineer and fireman. After the water is purified it goes directly from the tanks to an open heater where it comes in contact with the exhaust steam from the engine;



Plan and Elevation of Tank for Purifying Water for Locomotive Boilers.
The We-Fu-Go Co., Cincinnati, Ohio.

here it takes up a certain amount of lubricating oil from the steam. It is then pumped from the heater through a pressure filter which removes the oil, grease and any floating residue which had not settled. The heater ran seven weeks without cleaning, and then only a small deposit was found on the plates, where formerly they had from 3 ins. to 4 ins. on the top plate alone, and slightly lesser amounts on each of the other six plates. Formerly two wheelbarrow loads of deposit were taken from this heater every two weeks; now, only a small shovelfull once in two months. The boilers, which formerly contained from 1-16 in. to 3-16 in. of scale are now almost free from scale in the front end, and each time they are cleaned a large amount of the old scale is readily scraped off because it is getting soft and rotten. No new scale is forming at all, nor is there any indication of corrosion, so eventually the boilers will be clean, and can be safely kept in that condition.

At Columbus, O., a 2,200 HP. purifier has been in operation since April 26, of this year. The raw water contains about 32 grains to the U. S. gallon. After purifying, the total residue varies from 10 to 14 grains per gallon, of which from 0.467 to 1.25 grains is lime, the rest organic matter, iron, alumina, silica and soda. There are over 8 grains of soda per gallon in this water. The plant consists of one 55,000-gallon tank, 24 ft. in diameter by 18 ft. high. After the raw water is treated and has settled, a black speck the size of a pea can be seen on the bottom of the tank through 18 ft. of perfectly bright, clear water. From the tank the water is run into a cistern from which it is pumped into the heaters, and through the economizer into the boilers. The water has been evaporated in a new battery of Stirling boilers and after three weeks run they show no sign of scaling. In the old boilers a cleaning chain could not be pulled through, except by jerking a few inches at a time; now the chain will fall through the tubes. The heaters and feed pumps are cleaning out so that they contain less scale or limy deposit now than they did the first week they were put in service. The indications are that the purifier is doing its work, and at a cost of about 6 cts. per 1,000 gallons. In this plant the water is not filtered after it leaves the heaters.

What has been done in stationary plants can be done for railways, and although the water varies at different water stations, this variation is in the amount rather than in the character of the impurities. Each water would require a different amount of each chemical employed, but by means of printed direction cards at each water station no error would be likely to arise, provided the tank tender followed the directions given.

ANNUAL CONVENTION OF THE NEW ENGLAND WATER-WORKS ASSOCIATION.

The fifteenth annual convention of the association was held at Lynn, Mass., on June 10, 11 and 12, nearly 200 members and guests being in attendance. The convention opened with an address of welcome by Mayor Bessom, of Lynn. After this the president, Mr. Desmond Fitz Gerald, M. Am. Soc. C. E., delivered an address. He called attention to the growth of membership from 27 in 1882 to 529 in 1896, and also to the new permanent headquarters of the association, opened May 20, in Tremont Temple, in conjunction with the Engineers' Club of Boston. Books and pamphlets are desired for the library, which it is proposed to make a valuable feature of the new quarters. The president expressed the hope that at some future time there may be held an international water-works congress.

The treasurer, Mr. Geo. E. Batchelder, reported a balance of $2,704 in the treasury of the association.

The first paper read was by Mr. John C. Haskell, of Lynn, and was entitled:

How to Secure Pure Water from a Surface Water Supply.

At the outset Mr. Haskell made the following interesting statement regarding the studies of the character of the water supply of Lynn:

I will at this time state that we have in the basement of the city hall a laboratory in which biological examinations are made weekly of samples of water taken at points 1 ft. below the surface and 1 ft. above the bed of all our ponds. During the meeting of this association drawings showing all of the different organisms that have at any time been discovered in our water supply, also an opportunity to examine such organisms as are at present to be found in any of our ponds, together with an explanation of the details necessary to a thorough study of the character of the water, will be open to the members of the New England Water-Works Association.

Mr. Haskell then proceeded to discuss some of the characteristics of surface water supplies and especially those offensive tastes and odors so common to some such waters, and also the color which they sometimes have. Regarding color as caused by swamp water Mr. Haskell said:

This danger should be eliminated as far as possible by separating the swampy portion of the watershed from the hilly, by ditches at the edge of the swamps sufficient in size to carry the water from the upland around the swamps. Where the depth of soil will admit, the water table of the swamp should be lowered by means of ditches to the gravel or sand below the soil, thus requiring the water to simply pass downward a few feet through the soil to the gravel below, instead of a long distance through the surface of the swamp.

A practical result in this direction is shown as resulting from work upon the watershed of Walden Pond in 1895, which reduced the color of the water in the pond, as shown by the weekly examinations, from 76 to 1895 to 43 for the corresponding time in 1896. This reduction in color is perceptible and can be expressed in figures; undoubtedly the diminution in taste and odor, which can not be shown so clearly, was greater.

Coming to the storage reservoir, reference was made to the recent change of opinion among engineers regarding the advisability of stripping reservoir sites. The old idea that in a few years' time nature would do what man had neglected has in some cases proved erroneous.

The water supply of Lynn is taken from impounding reservoirs. The first two constructed, Breeds and Birch Ponds, were largely purified by natural causes, but in Walden and Glen Lewis ponds it has been different, no perceptible improvement being shown in the latter. The attempt to improve the summer condition of the water in Walden Pond was described by Mr. Haskell as follows:

In our endeavor to accomplish this result and with a view to ascertain as nearly as possible whether the results to be obtained by removing all soil from the bed of the pond might not be equally well subserved by a covering of gravel or sand over the soil to a sufficient depth to effectually destroy its pernicious effect on the water, a portion of this area, containing mud from 15 to 35 ft. in depth, was selected as an area upon which the expense of removal would be practically prohibitive; also one where the chances of failure to secure good results were most likely to be found.

The surface of this area was mud, with water standing near and upon a portion of its area, it being of such a nature that gravel would readily sink to an unknown depth. All stumps within this area were allowed to remain. Other stumps were removed from the adjacent area from which all soil was to be removed and placed over the muddy area to form a more stable bed than the wet soil, finally covering all with about one foot of gravel. The bed of the pond was burned over and was exposed to alternate freezing and thawing through the winter. The success attendant upon this effort is shown from the fact that the water became unfit for use on May 25, 1893, and on May 23, 1894, but in 1895 the water remained a good, potable water, remarkably free from algae growth until July 10, a sufficiently late date to furnish the needed supply, when it was again wasted to permit further work in this direction. An examination of the different exposed areas showed an equally good appearance of the covered areas and those from which all soil was removed.

Immediately after the bed of the pond was exposed to view, samples of the gravel from the areas cleared and soil from the areas not disturbed were taken to determine as far as possible what advantage was gained by our labor.

These samples, in equal numbers from the sand and soil, were collected at points not more than two feet distant from each other and placed in a dish of water to develop all animal and vegetable life that could be germinated. In the specimens taken from the soil, most of the species of organisms previously found in the waters of the pond were well enough preserved to commence an active growth. The samples of gravel contained practically nothing, although gathered in such close proximity to the others.

The author next points out that while the removal of organic matter from reservoir bottoms is a step in the right direction, it is possible that the matter brought into the reservoir in the form of wash from fields may furnish food and resting places which will contribute to the development of troublesome organisms, and cites experience with a distributing reservoir as tending to prove this.

In the brief discussion of this paper Mr. Haskell stated, in reply to a question from Mr. H. G. Holden, that the water was let out of the pond during the winter to get rid of organisms, seeds and spores. Mr. X. H. Goodnough believed cold weather had a good effect upon stored water. Mr. Fitz Gerald thought that freezing a reservoir bottom was insufficient. Mr. Haskell stated that he thought 6 ins. of sand on the reservoir bottom would be sufficient, but he had been using 12 ins.

The Financial Management of Water-Works.

This was a carefully prepared paper, accompanied by four tables of statistics relating to 66 water-works. Mr. Coffin answered some questions raised at the Boston meeting of the association, in 1894, regarding the financial management of water-works under municipal control. In general, the paper centered round the questions, are municipal works self-sustaining, or are the rates charged private consumers too low, throwing the burden of the works onto the taxpayers rather than the consumers, and rolling up bonded indebtedness where improvements should be paid from the revenues?

The author found it necessary to define some of the terms entering into his discussion, on account of the divergencies in water-works book-keeping. This was especially necessary as regards the construction and maintenance accounts. Under construction, assuming the works already built, Mr. Coffin would include all extensions, including main and service pipes, all improvements and all renewals on account of deterioration or insufficiency. Under maintenance would come salaries of permanent officials and employees, care and repair of plant, other operating expenses, interest and depreciation.

Revenue should of course include all sums derived from private consumers, in addition to which the works should be credited with a sum equal to the actual expense of providing for fire protection and other public purposes. This is necessary because consumers and taxpayers are not identical, and because the cost of construction and operation is increased by making provision for fire protection. The increased cost of works due to fire protection, Mr. Coffin estimated at 100% each for pumping machinery and mains, 33⅓% for pumping stations and 75% for reservoirs or stand-pipes. The increase in maintenance he put at 100% for care and repairs of pipe system, 33⅓% for pumping expenses and 75% for interest and depreciation. The quantity and quality of the original supply and the office expenses he did not consider as increased on account of fire protection. The total increase, the yearly charges, operating and fixed, he put at from 33 to 43%.

Roughly speaking, he stated that where not over 50% of the total revenue was raised by direct taxation a proper public charge for fire protection would not be exceeded.

As a figure for general application, three gallons per capita was given as the use of water for public purposes, other than fire protection, and 15 to 20 cts. per 1,000 gallons as a fair price for such water.

The above and other principles set forth in the paper Mr. Coffin had used in tabulations and computations relating to some 65 water-works, mostly in New England. From a vast array of figures, Mr. Coffin showed that of 52 works there were 14 in which the revenue from private consumers is sufficient to meet the total annual expenditure, including interest and depreciation; 19 in which the

sum of this revenue and that estimated for public purposes, but not including fire protection, will meet the total expense; while for the remaining 33 plants there would be deficiencies ranging from 0.8 to 57.3%, but exceeding 50% in only four cases, the maximum amount which he had allowed as chargeable to fire protection. Mr. Coffin, therefore, concludes that as a general thing the private rates of works in question are high enough, as the works are now operated.

In discussing the paper Mr. J. C. Whitney said he thought six gallons none too much allowance for the amount of water used for public purposes, excluding fire protection. Mr. F. L. Fuller, M. Am. Soc. C. E., urged the necessity of testing mains for leaks. Mr. Coffin spoke of the lack of proper records of consumption, especially on gravity systems. Mr. FitzGerald urged that in laying pipe where the head was small great care should be taken with the work in order to lessen the friction.

The Making of Cast-Iron Pipe.

At the Wednesday evening session the above process was described by Mr. Jesse Garrett, of Philadelphia. Some 60 stereopticon views were shown, including the plants of the Cambria Iron Co. and R. D. Wood & Co. Mr. Garrett first gave some historical matter relating to water pipe and then set forth in detail the present practice in making cast-iron pipe. Mr. Garrett was assisted by Mr. C. S. Prince, of R. D. Wood & Co., who stated the practice of his company. Discussion was postponed until Thursday morning, when Mr. A. F. Noyes, M. Am. Soc. C. E., urged the importance of proper specifications and the desirability of engineers and foundrymen working together.

The discussion on "Protective Coatings for Cast-Iron Pipe," which was to have been opened by Mr. Dexter Brackett, M. Am. Soc. C. E., was omitted.

Utilizing a Spring as a Source of Water Supply for a Town.

A paper with the above title was presented by Mr. Louis E. Hawes, C. E., of Boston. It discussed in detail the conditions that give rise to springs and the development of a number as sources of public water supply. Records of the yield of some of these springs before and after development showed an increased yield in the latter case. The paper contained many interesting features to which we hope to call attention in a later issue.

Method of Connecting Driven Wells to Suction Main and Connecting With the Pump.

This paper was read by Mr. F. F. Forbes, of Brookline, and described some interesting work done under his direction.

After the discussion of the paper was begun Mr. Forbes stated that ordinary wrought iron pipe had been found more serviceable than galvanized iron, the latter giving up its zinc to the water. If a well fills with fine sand a diaphragm pump is used to remove the latter.

There was no business session Thursday afternoon and in the evening the number of papers to be presented rendered the discussions brief.

Some Observations on the Relation of Light to the Growth of Diatoms.

The above paper was presented by Mr. Geo. C. Whipple, who has done a large amount of biological work in connection with the water supplies of Boston and Lynn. It was founded on experiments and observations and showed that the growth of diatoms is largely dependent on light and consequently diminishes as the depth and color of water increases. In dark waters the limit of growth is about 8 ft., and in light, about 15 ft. below the surface. A comparison of diatom growths in 57 reservoirs and ponds in Massachusetts, given in the reports of the Massachusetts State Board of Health, corroborates the above statements and indicates that an abundant food supply is also a favorable condition to the growth of diatoms.

Mr. Forbes said, in discussing the paper, that the diatoms in the Brookline reservoirs differed as much in nature and habits as the plants that can be seen with the naked eye, and that 10,000 different diatoms had been named. Diatoms are brought to the surface by the vertical movements of the water and are particularly abundant in winter at Brookline.

Recent Specifications for Pumping Engines for the Water-Works of the City of St. Louis, Mo.

A discussion of the above specifications was submitted by Mr. F. W. Dean, M. Am. Soc. M. E., as follows:

I have been requested by your president to discuss the specifications for two pumping engines for the city of St. Louis, which have recently been issued. The specifications are the work of Mr. M. L. Holman, Water Commissioner of St. Louis, and a member of our association. They are for vertical triple expansion engines of 15,000,000-gallons capacity in 24 hours, and bear the same evidence of care and ingenuity in their preparation that has characterized all of the St. Louis specifications since 1889.

Mr. Holman has well-defined ideas as to what is desirable in a pumping engine, and the specifications are so prepared as to prevent their evasion. They are so ingeniously interwoven with triangular construction and so strongly tied together that Mr. Holman is fond of characterizing them as being "loaded." With all this they are among the best ever issued.

In the desire to make a cheap engine, a designer may think that he will design a small engine and run it fast, when he notices that the specifications say that the plunger speed must not exceed 200 ft. per min., which is very slow. If he then thinks that he will make the plungers of shorter stroke than the steam cylinders, in order to make the pumps short and cheap, and the steam cylinders small in diameter, he finds himself balked by the clause that states that the diameter of the plungers is not to exceed 44% of the stroke. He finds, also, that the minimum area of the water way through the pump valves is stated, so that he is unable to economize in valves, nor in pump cross-section area, in the vain hope of making a less costly design than his competitors. About this time the designer concludes that he will design an engine as Mr. Holman wants it.

Besides this, the successful bidder of the previous set of engines for the same place, finds that these specifications differ from former ones sufficiently to prevent his using his old patterns, and thus the work is thrown open to everybody, giving the city whatever advantage may come from this.

An acquaintance with the specifications issued for a number of engines for the St. Louis Water-Works, beginning in 1890, shows that the Holman "idea," if I may so characterize it, is slow speed for everything, for moving parts of the engine, and for the water. This is in itself, from various points of view, advantageous, and contributes to comfort of mind. When an engine contract is open to competition, and the lowest bid is to be accepted, as is always the case at St. Louis, slow speed is comforting, for an unskilful designer is far more likely to be successful with slow speed than with fast.

In connection with this, however, it is undoubtedly a fact, that in the hands of a skilful designer a pumping engine can run two or three times as fast as the St. Louis engines are to run, and with fully as much satisfaction and durability. The secrets of this, if they are secrets, are large water ways, large suction air chambers, rubber valves, small lift of valves, and large discharge air chambers. Looking a little beneath the surface, this means quick moving machinery with slow moving water and great elasticity of cushion for the water. Moreover, the elastic cushions should be as near the seat of disturbance as possible.

There is ample evidence of the truth of this theory, for there are many pumping engines, having the above qualities, that have actually been improved in working by being speeded up.

There is a disadvantage in making as powerful an engine as the St. Louis engines are to be, slow running, on account of their enormous size. In this case the horse-power of each engine is 900 at the steam end, which is greater than in any other case that I know of. This requires a low pressure cylinder fully 96 ins. in diameter of bore. If the plunger speed could be made 400 ft. per min. the diameter of the low pressure piston could be 68 ins., which would lead to considerable comfort of mind, also, especially to the foundry that casts the cylinder.

Not a little of the interest attaching to these engines lies in the fact that they are to pump directly into the city mains, and that they are to have relief valves to discharge their whole capacity back into the suction pipe when the mains cannot receive it.

It is customary to build a masonry foundation from the bottom of the pump pit up to the bedplate of the engine, but in this case the iron work is to begin at the bottom of the pit, which is 36 ft. deep. This is indeed a bold departure, and is a boon to iron foundries.

After these engines are erected, all parts containing water are to be subjected to a pressure of 200 lbs. per sq. in. This will of course test the principal reciprocating parts, and this test is a very important feature.

The duty trial is to be of 24 hours' duration, and the duty must be guaranteed to reach 135,000,000 ft. lbs. per 1,000 lbs. of steam consumed, which is the highest guarantee ever required, so far as I know.

It is well known that when new engines are started large quantities of oil are used, and doubtless Mr. Holman has found that if the city pays for the oil it is used extravagantly. To overcome this expense to the city the specifications require the contractor to furnish all oil and grease used during the first six months.

There is only one more point that I wish to refer to, and that is if the duty of the engine falls below the guarantee the contractor is to lose at the rate of $2,000 for each 1,000,000 ft. lbs. that the duty falls below, and is to receive a bonus at the rate of $1,000 each one 1,000,000 that it surpasses the guarantee.

This is due in equity to both parties, and will bear a little discussion. If a guaranteed result is not accomplished, the purchaser is not receiving that which he is entitled to, and thereby is subjected to an annual expense which he is in no way causing. He should therefore receive from the contractor, or withhold from him, a sum of money, which put at interest will yield him the extra cost of running the plant. This will make him just whole. In other words, the contractor should lose the capitalization, at the ruling rate of interest, of the annual extra cost of running the plant, due to the inferiority of the engine.

In the other case of an excess of duty, as this has cost the contractor nothing, no reason can be given for paying a bonus. The purchaser can by courtesy pay a bonus, but he cannot pay the whole capitalization of the annual saving produced by surpassing the guarantee, for then he would be no better off by having the better engine. He can, however, well afford to divide this equally between himself and the contractor, and thus hold out an inducement to furnish an extra good engine.

There was no discussion on the above. The last paper to be presented was on

The Water-Works of Cambridge, Mass.,

and was by Mr. L. M. Hastings, City Engineer of Cambridge. The paper was brief. It opened with a historical description of the works, after which extensions now under way were described.

The supply is impounded in Stony Brook basin, formed by a dam constructed in 1887, and having a capacity of about 350,000,000 gallons. A 30-in. cast-iron conduit nearly eight miles long leads from this basin to Fresh Pond, which has a capacity of about 400,000,000 gallons. The waters of Stony Brook and Fresh Pond are pumped to a reservoir and stand-pipe in the city.

The average daily water consumption of Cambridge in 1895 was 6,000,000 gallons, 72 gallons per capita. The available yield is 6,000,000 gallons from Stony Brook and 1,250,000 from Fresh Pond. More storage is being secured by providing another reservoir formed by two dams, this part of the work being described by Mr. Hastings as follows:

Both dams are built mainly of earth and have concrete core walls; both carry a highway on the top. The main dam, at Winter St., is 35 ft. wide on top, with slope of 1½ to 1 on the water side, and 2 to 1 on the lower side. The core wall, 7 ft. thick, is carried to the bed rock. The length of the dam is about 1,000 ft.

This dam is pierced by a large overflow conduit or waste way about 7 ft. in diameter, located at the bed of the brook. Flash boards in a chamber built at the end of this conduit regulate the height of the water, and with a relief waste way or overflow in the crest of the dam and at one end, provide an outlet for freshet water. The water in the basin controlled by the dam will be 165 ft. above the level of the water in Fresh Pond.

It may be of interest to quote a few prices at which the work of construction at this dam is being done in quite a satisfactory manner: American concrete, of the usual proportions, is being placed at $5.10 per cu. yd., and Portland concrete at $4.75 per cu. yd.; plastering of Portland cement, ¼-in. thick, 27 cts. per sq. yd.; excavation and construction of dam, 38 cts. per cu. yd. Field stone slope paving is being laid at $1.10 per sq. yd. Brick masonry in Portland cement mortar costs $10.29 per cu. yd. Broken stone is furnished and placed at 89 cts. per cu. yd.

The dam at Lincoln St. is much the same in design as the one at Winter St. It has a length of about 600 ft. and a width on top of 27 ft. A few of the prices paid here are as follows: American concrete, $4 per cu. yd.; plastering, 10 cts. per sq. yd.; earth embankment construction, 27 cts. per cu. yd.; field stone slope paving, $1 per cu. yd.

The basin, when filled, will be about 650 acres in extent and about 2½ miles in length. It will store about 2,000,000,000 gallons, and give about 1,500,000,000 gallons available for use. The entire bed of the basin is to be stripped of soil and muck, necessitating the removal of about 1,900,000 cu. yds. of material. Prices for the work have ruled very low, ranging from 16 to 25 cts. per cu. yd., the major part being done for about 20 cts. per cu. yd. The work is being done almost entirely by the old fashioned, yet effective machine, a one horse dump cart.

From the storage basin formed by these dams, the water is to be let down the natural bed of the brook to the lower basin at Stony Brook, and thence by the iron pipe conduit to Fresh Pond. It is proposed to eventually construct another pipe of larger dimensions, parallel with this conduit from the Stony Brook Reservoir to Fresh Pond.

A 20,000,000-gallon pumping engine is being built after the designs of Mr. E. D. Leavitt, M. Am. Soc. C. E., by the Groshon High Duty Pumping Engine Co. of New York. The engine will be 53¼ ft. high, with a 25-ft. fly wheel, and will pump 229 gallons per stroke.

A 40-in. riveted steel force and supply main will force water to a new reservoir. This main is made from 5-16-in. plate and coated by means of the Sabin process, with a special asphaltum varnish, baked on.

At two points the pipe was carried over deep cuts, with clear spans of 75 and 94 ft., the pipe here being made from ⅜-in. plates. The 94-ft. span was reinforced by riveting to the top and bottom two heavy 6-in. angle irons, extending about two-thirds of the length of the span. Expansion joints were placed at each end of each span.

The contract price of the work was $4.57 per lin. ft. for the pipe in the trench, tested and ready for use. The city did the trenching and refilling at an expense of about $1.50 per ft., making the total cost about $6.07 per ft. About 24,500 ft. of 40-in. pipe will be required, including fittings; 8,400 ft. of trench containing two mains, force and supply, about 18 ins. apart. The valves used are 36-in., made by the Coffin Valve Co., of Neponset, Mass.

An accident that occurred during the construction of the pipe line is described by Mr. Hastings, as follows:

While the pipe was being laid a curious accident happened, which illustrates the flexibility of even a pipe with as large a diameter as 40 ins. A stretch of pipe had been riveted up and awaited testing, the trench being in low ground, and not refilled. Oct. 13 and 14 a very heavy rain came and filled the low portion of the trench, and about 425 ft. of the pipe floated up, having less specific gravity empty than water, rising about 3 ft. in places. The trench was dried out and the pipe forced back in place by loading on top, with but little damage to pipe or riveting.

A 44,000,000-gallon reservoir is being constructed at Payson Park to increase the pressure, and when completed the whole city will be supplied from it. The reservoir will be in two compartments, divided by a masonry wall, the bottom and slopes being lined with concrete. The heart wall will be of field stone, laid solid in cement, and resting on the sheet of concrete at the natural surface.

The improvements outlined are estimated to cost from $1,250,000 to $1,500,000.

Business and Pleasure.

A total of 16 new members were elected during the convention. The following were the principal officers chosen for the ensuing year: President, Mr. John C. Haskell, Lynn, Mass.; Secretary, Mr. J. C. Whitney, Newton, Mass.; Treasurer, Mr. G. E. Batchelder, Worcester, Mass.; Editors of the Journal, Messrs. Allen Hazen, of Boston, and W. H. Richards, of New London, Conn. With the exception of the president all those named served in the same capacities last year.

On Thursday afternoon, at the invitation of the Water Board of Salem, Mass., the association visited that historic town, where they were received at the house of Mr. John F. Hurley, President of the Salem Water Board, and a luncheon was served. Later in the day a fish dinner was enjoyed at the Salem Willows. On Friday afternoon, through the courtesy of the Lynn Water Board, a drive was taken through the Lynn Woods and Parks, and the water system was inspected, after which there was a dinner at Nahant. The exhibits of water-works appliances are mentioned under Industrial Notes, elsewhere in this issue.